JOURNAL of the AMERICAN WELDING SOCIETY

Vol. 10
No. 3
MARCH
1931

WM. SPRARAGEN
Editor

AMERICAN WELDING SOCIETY

EDITORIAL AND BUSINESS OFFICES

33 West 39th St.
New York, N. Y.

Preliminary Notice

Annual Meeting
American Welding Society
New York
April 22, 23, 24
Engineering Societies Building

Important business sessions, annual dinner, technical sessions and inspection trips are scheduled.

Technical sessions include important papers on Ship Construction, papers and code on Welded Piping, Resistance Welding, Structural Steel Welding, Research Reports, Alloy Steel Welding, Thermit Welding and numerous other subjects.

A complete program is being sent to all members of the Society. Others may obtain copy upon request of Secretary.

BOUND VOLUMES

Bound volumes of the Journal for the year 1930 are now available in attractive imitation black leather covers. This volume contains a wealth of information on all phases of welding. Price per copy $5.00. Subject and Authors' Indices permitting easy reference are included. A few bound volumes for the years 1924-to-date, are still available at $5.00 per copy.

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JOURNAL OF THE AMERICAN WELDING SOCIETY

VOLUME X | MARCH, 1931 | NUMBER 3

ANNUAL MEETING PROGRAM

For a preliminary announcement of the Annual Meeting program which will be held in New York, April 22 to 24, see page 1—"title page" of this issue of the Journal.

Presentation and Publication of Papers

(Prepared by the Meetings and Papers Committee and approved by the Executive Committee)

Opportunity and Responsibility in Presentation of Papers

The growth of the welding industry continues at a rapid rate. New applications are constantly being made and new techniques developed. Research is extending the frontiers of welding knowledge in every phase of the art. Codes and standards are being promulgated. Behind this growth lie not only the innate capabilities of the welding process, but the cooperative efforts of those who are identified with the welding industry. Perhaps the greatest single factor in such progress is the free and rapid interchange of ideas and facts.

The presentation and preparation of papers before national meetings and local sections is one of the most important activities of the Society. From the standpoint of the individual concerned, the presentation of a paper is an opportunity to contribute to the pool of knowledge and experience, from which all benefit.

An opportunity is always open for any member to present a paper of general interest to the industry at a Society meeting or to have his contribution published in the Journal without oral presentation.

General Information and Suggestions for Authors

The Meetings and Papers Committee invites any member of the American Welding Society, or others interested in the aims of the Society, to submit papers containing material pertinent to those aims. Papers may be submitted either for oral presentation at a national or sectional meeting, together with publication in the Journal, or for publication without oral presentation.

The criterion of the suitability of material is its value to a large proportion of the membership of the Society. The responsibility for selection of papers to be presented at national meetings or published in the Journal is vested in the Meetings and Papers Committee. Selection of papers to be presented before local Sections is vested in the local Sections.

Since programs for national meetings must be arranged several months in advance, if a paper is submitted for oral presentation, the Meetings and Papers Committee should be notified as early as possible of its availability, and furnished with an outline of its contents and a statement as to what equipments if any (projection lantern, blackboard, etc.), would be required for its presentation.

If the outline is found to be suitable the author will be so notified. He will be advised as to the time and place of the meeting and invited to suggest the names of those qualified to discuss the paper. In order to allow time for discussion to be prepared it is desirable that papers to be presented at national meetings be published in the Journal prior to the meeting, and to this end the complete manuscript should be furnished to the Editor at least 40 days prior to the meeting.

Papers should be typewritten with double spacing and the manuscript mailed flat (i.e., not rolled). The author's business affiliation should be clearly indicated.

Subject Matter

The paper should contain new material. The results of research, data for design, cost figures, descriptions of unusual technique, and similar practical information are particularly desired. Such papers will be given preference both as to time of publication and space in the Journal.

Papers should be condensed as much as possible without detracting from their interest or omitting vital information. Material that is merely of an advertising character should be omitted.

Preparation of Papers

The writing of a paper is greatly simplified by first preparing an outline of the main divisions of the subject with subheads to cover subdivisions. Corresponding heading should appear throughout the paper and be descriptive of the material immediately following.

A long generalizing introduction, not intimately related to the subject, should be avoided. The paper should proceed in logical order from the premises to the conclusions. Every statement should be clear, definite and concise. The major conclusions, if any, should be listed at the close. The relation of these conclusions to previous theory and practice, and the indicated advances, or the observed limitations, should be brought out.

The nomenclature* should conform to that established by the Society. References to the work of others should give the name of author, title of his paper, and place and date of publication.

Illustrations

Illustrations that make clearer the thing described are desirable, but only those conveying information of value and interest to the reader should be submitted. All figures (diagrams, photographs, etc.) should be numbered consecutively. Their significance should be suitably explained in the text.

It is preferable that all captions should be type-set, and for this purpose a list of figure numbers with captions should be furnished. For identification the author's name, the figure number and the caption should appear on the margin or back of the illustration in such a way that they will not be reproduced or mar the photograph.

Line drawings should preferably be made with black ink, on tracing cloth or plain white paper without closely spaced cross-section lines. The lettering should be large and legible and with open spacing to permit good reproduction. The proportions of drawings shall be suitable to the page size of the Journal.

Oral Presentation

Long papers when presented at a meeting should be given in abstract. The presentation should usually not exceed 20 minutes, in order to allow time for discussion and for the presentation of other papers. It is suggested that the abstract be prepared and timed in advance in order to assure a brief but comprehensive presentation.†

In presenting papers, authors should

*Published in the November, 1929 issue of the Journal of the A. W. S., and also available in bulletin form.

†*Note:* About 100 words can be presented per minute.

speak loudly and clearly so as to make their delivery effective and audible to all. If lantern slides are used the author should endeavor to address the audience by facing the screen as little as possible when explaining the slides. When illustrated copies of the paper are available to the audience lantern slides need not be used.

Discussions

Stenographer's transcript of oral discussion will be mailed to each participant with a request for careful revision and return within one week from date of receipt. If not returned within 10 days, it may be published as revised by the Editor.

Written discussion may be submitted within 30 days after the presentation of a paper, or within 30 days after publication in the Journal if it is not orally presented. If a too lengthy discussion is submitted the discussor may be requested to condense his discussion or to replace it by a paper for independent publication or presentation.

Copies and Reprints

Six copies of the Journal containing a particular paper will be furnished to the author without charge. Separate reprints of any paper still in type may be secured at cost. If reprints are desired the Editor should be notified in advance of printing, so that the type will not be destroyed.

Publication Elsewhere Than in Journal

Authors submitting papers for publication in the Journal shall not submit them to other publications unless this is clearly indicated in the accompanying letter of transmittal.

All papers presented at national or section meetings shall be the property of the A. W. S. Publication elsewhere of any paper (in part or whole) is permissible providing proper acknowledgment is given to the author and to the Society and providing it is not published prior to its presentation.

Editorial Reservation

The Meetings and Papers Committee reserves the usual editorial privilege of making such omissions or amendations in papers and discussions submitted as it deems advisable. Unless the participants stipulate otherwise, minor changes will not be resubmitted to him.

Rules of Procedure for Meetings and Papers Committee

The Society shall publish and distribute free of charge to its members a monthly publication to be known as the JOURNAL OF THE AMERICAN WELDING SOCIETY. The immediate supervision of the work and the handling of publication details shall rest in the hands of an Editor, who shall, however, at all times be responsible to the Meetings and Papers Committee. In case of doubt as to policy in regard to editorials, advertising and technical papers, the Editor shall call upon the Meetings and Papers Committee except that in case of a disagreement it shall be referred to the Executive Committee of the Society.

The Journal may include editorials, news items, technical reports and papers, employment service bulletin, bibliography of current welding literature, advertising and other items arranged from time to time by the Meetings and Papers Committee

The Editor of the Journal shall ex-officio be Secretary of the Meetings and Papers Committee.

The Meetings and Papers Committee shall be in charge of the arrangement of the programs for the Annual and Fall meetings of the Society and any other national meetings.

The Meetings and Papers Committee shall assist the local sections in securing suitable programs for their monthly meetings.

The Meetings and Papers Committee many not incur any expense in connection with national meetings or publications unless provided for in the annual budget. The Editor of the Journal shall be required to manage publication costs in such a way that the total for the year shall not vary more than 5 per cent from the allotted budget. Modifications in the budget and other special arrangements may be made upon approval of the Executive Committee.

All sections are requested to send copies of all papers presented at their monthly meetings promptly to the Editor of the Journal. Those papers selected by the Editor (subject to supervision of Meetings and Papers Committee) shall be published in the Journal of the Society. The Editor shall cooperate with trade journals desiring to reprint papers and abstracts of papers. The Meetings and Papers Committee may arrange publication of any paper with trade publications and other journals.

Reports of the American Bureau of Welding, technical and other committees of the Society, selected for publication, shall be published in the Journal. Such reports shall, however, receive the necessary approval of the American Bureau of Welding and the American Welding Society before being released for publication.

Members of the American Welding Society and others interested in welding shall have the privilege of writing technical papers and submitting them for the consideration of the Meetings and Papers Committee. Papers selected for publication shall be published at the earliest convenient time in the Journal.

The Editor shall advise within 20 days after receipt of a paper whether or not it will be published in the Journal. Failure of such notification will allow the author the privilege of submitting the paper to other publications.

Papers dealing with the results of research investigations, details as to technique and kindred papers will be favored both as to time and space.

Papers presented before joint meetings with other Societies shall be treated as special cases and the rights of cooperating organization shall be fully recognized.

SECTION ACTIVITIES

BOSTON

An attendance of about two hundred members and guests heard J. F. Lincoln, President of the Lincoln Electric Company, Cleveland, Ohio, on Friday evening, February 20. Mr. Lincoln spoke on the fleet weld process, and about fifty lantern slides were used to illustrate his talk. After the discussion period, actual demonstration welds were made.

The March meeting of the Society will be an afternoon visitation trip to the Watertown Arsenal. The exact date of this meeting has not been determined as yet.

CHICAGO

W. B. Keelor, Welding Supervisor of the Whiting Corporation, presented an illustrated paper at the February meeting of the Chicago Section, held February 6, at the Palmer House, Chicago. The subject of his paper was "Welding and Cutting in the Manufacture of Heavy Duty Equipment." An interesting feature of Mr. Keelor's paper was the description of the procedure control, which has been worked out by his company, in successfully using the welding processes.

A second paper of the evening was presented by C. C. Whittier of the Robt. Hunt Company, consulting engineers, Chicago. Mr. Whittier indicated in his paper, and with slides, how the testing laboratory can be of use to the welding department of the industrial plant using welding.

Over a hundred members and guests were in attendance, many of whom arrived for the dinner which is served in the meeting room prior to the meeting itself.

CLEVELAND

The Cleveland Section held its regular February meeting in conjunction with the Welding Conference at Case

(*Continued on page* 51)

Fabricating Sheet Metal by Arc Welding

By E. P. BESTLER

✦ This paper was presented at the January 9th meeting of the Chicago Section, A.W.S., by E. P. Bestler, Supt., Sheet Metal Dept., Raymond Bros. Impact Pulverizing Co.

IN this paper I will try to bring out the advantages of fabricating sheet metal by arc welding compared with the old system of riveting and soldering, as illustrated by the work done in our own shop.

Our work does not have to test up to any great degree of pressure, but calls for a dust-tight job. About nine years ago 100 per cent of our work was constructed of galvanized sheet steel riveted and soldered. Today, I can safely say about 95 per cent of our work is constructed of black iron welded.

There is a saving of about 28 per cent in the raw

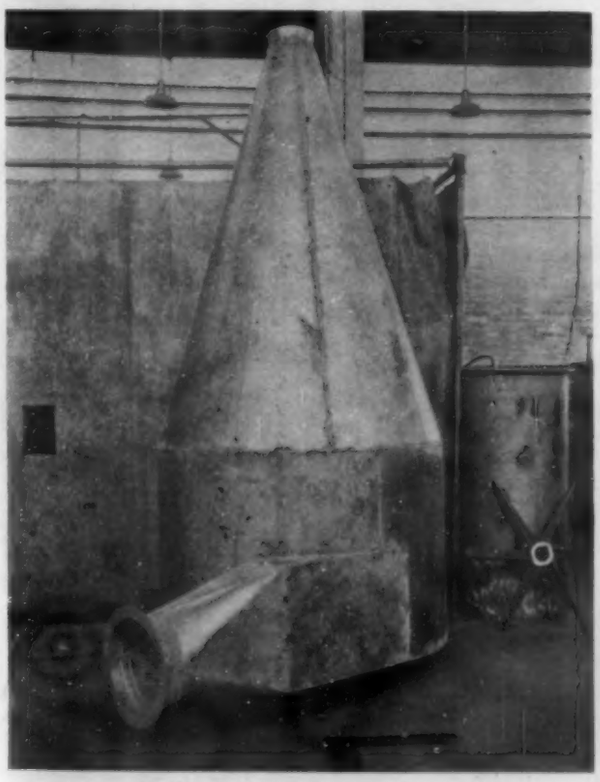


Fig. 1—Cyclone Collectors Made from No. 20 Gage Material up to ⅜-in. Tank Steel. Completely Tacked Before Welding

material. There is also a saving of about 50 per cent in labor—I do not mean to state a 50 per cent saving in all classes of work, but I can safely say about 75 per cent of our work shows this saving over old methods.

One very important point of saving is in the laying out of the different shapes and forms of work. In developing a pattern for the riveted process, there is a great deal of time lost in laying out the rivet spacing and proper laps; whereas in developing a pattern for a welded job you cut on the developed line and you're through; that is, providing you cut on the line.

In cutting out the many shapes of sheet metal parts, there is a saving of time and material. Take, for example, a plain cone (Fig. 1) 8 ft. in diameter on one end, 1 ft. diameter on the other, and 10 ft. high, made of 3/16-in. tank steel. There is a saving of $1 or more in material by butt welding in place of using a lapped and riveted joint. Moreover, the butt welded

Fig. 2—Welded Elbows Made from 16 Gage Material up to 3/16 In.

job gives a much smoother job and there are no rivet heads to wear off by the tons of material passing over them, which is an important part in our work. Most of our work is shipped in sections and put together with angle iron rings and flanges. A large saving in time is effected by not having to draw in the large end of this cone to allow for riveting.

In the general run of angles (Fig. 2) of any degree or size, gages from No. 12 and heavier, there is a great saving of time by butt joining them, doing away with hammering out and drawing in of the edges to make one end slip over the other.

Take a compound angle, shown in Fig. 3, made out of No. 10 B. A. It would be a difficult task to turn

Fig. 3—Arc Welded Compound Elbow

over the edges for a riveted job or form an angle to fit into the corner. We encounter no trouble at all assembling a job of this sort. We make a corner weld wherever we can in rectangular and square work, making a very fast and good looking weld.

The same can be said of the piece of work illustrated in Fig. 4. It would be extremely difficult in this case

to hold the dolly to buck up against a heavy hammer blow, as in some cases these ducts are only about 12 in. high.

In the three-way branch (Fig. 5) we find it much less work to assemble for welding. We butt the parts, weld and cut out the different openings with the torch after the job is completely welded. What a lot of rivet heads would show up inside of this connection to make it dust tight.

In constructing a piece of work shown in Fig. 6

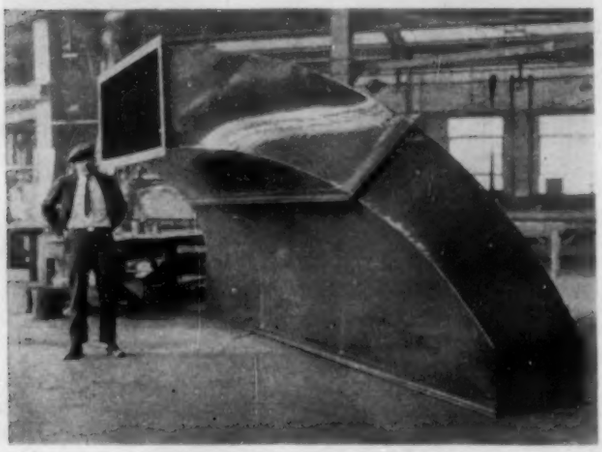


Fig. 4—Arc Welded Duct Used in Connection with a Preheated Air System

there is a great deal of time saved by the absence of flanging, punching and drilling.

In general practice a four-way distributor, illustrated in Fig. 7, is made of cast iron, but owing to the short time allowed for the job, there was not sufficient time to make wood patterns and risk spoiling one or two in the mold. Our engineering department there-

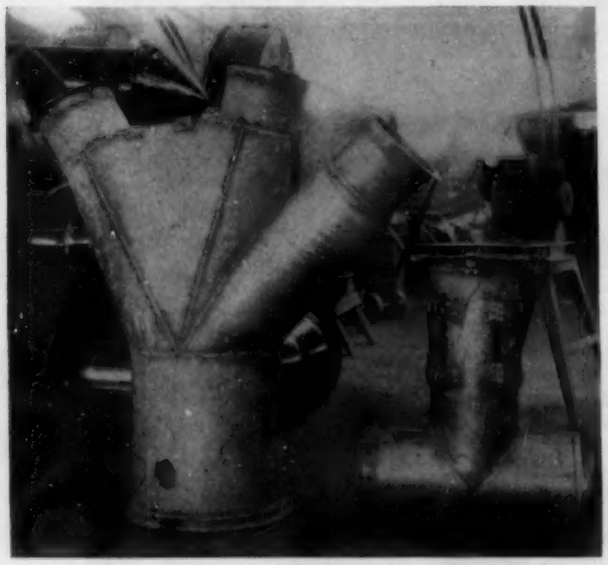


Fig. 5—Three-Way Arc Welded Hot-Air Duct

fore decided to make it of sheet steel, and as tons of material pass through this connection, it was made of ¼-in. tank steel. In two or three days, the distributor was on its way. The large end was 14 in. diameter and the small ends 7 in. diameter. The dimensions did not vary 1/16 in. in all directions. The ends of each branch came up to within a few inches of the large end or inlet end, tapered off to help direct the material. This is a piece of work which we are proud of and almost impossible to make in any other way.

I don't know whether to call the article illustrated in Fig. 8 a compound curve or a head twister; maybe the latter is more appropriate. Just try to drive rivets in those corners! What a nerve racking job it would be. You will surely have to watch your step in laying out as well as forming a piece of work of this sort.

Fig. 9 is an all-welded fan casing—an absolute dust-tight job, usually made of ⅛-in., 3/16-in. and ¼-in. material. By using the corner weld in this construction, it makes it easy to weld; and being smooth inside makes it an easy task to line.

In the lighter gages—No. 14 and lighter—we use the

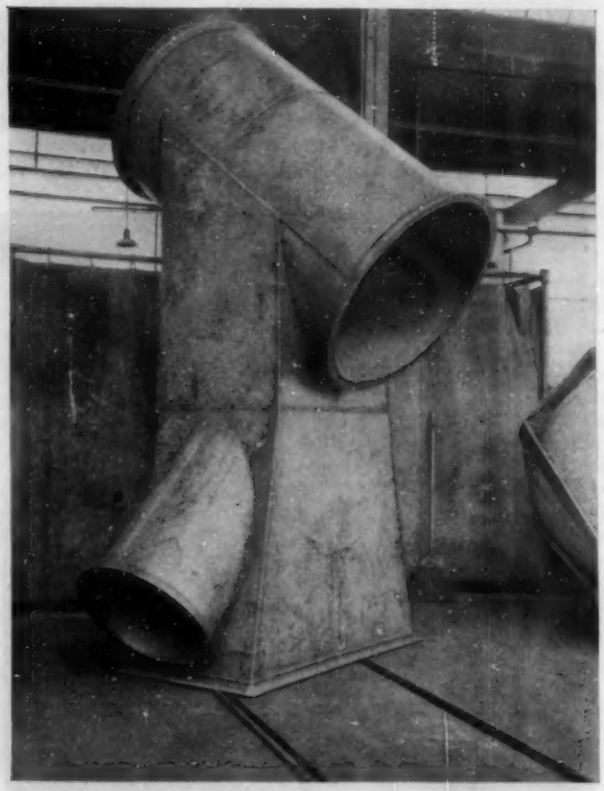


Fig. 6—Difficult Pipe Section Arc Welded

lap weld for large diameter pipes and elbows, using a spot welder to do the assembling, which brings the joints tightly together and permits a much faster weld than a butt weld.

We make most of our pipe flanges of rolled angled iron with the joints acetylene welded. We use the torch for the reason that it makes a stronger weld and requires no grinding after the weld.

We have two classes of welders: assemblers and welders. The assemblers work in pairs and only tack the work together; then lay it aside for a welder to complete. In this way all men are kept busy at all times and you do not have a man waiting for someone to give him a hand or have a man standing around watching the other man weld.

A man selected for an assembler must be a man who can read a blue print or sketch and have mechanical ability. Not being a productive shop, we cannot use

fixtures for our class of work, and thereby it requires men who can measure up and check a piece of work after assembling it.

We generally select men who show an inclination to become welders, and put them to work as assembler helpers. If they show any interest in the work, we

Fig. 7—Four-Way Distributor Made from ¼-In. Copper Bearing Steel for Powdered Coal Burning Plants. Large Opening 14 In. Diameter; Small Opening 7 In. Diameter

give them the right to play with the arc whenever they see an opening, and with the proper supervision of the experienced welder they become good welders and assemblers.

We use nothing but a coated wire, as we have both a.c. and d.c. machines. We aim to have a good appearing weld as well as a ductile weld. We take a great deal of pride in our work and we are pleased to say that we have a very good force of welders.

Fig. 8—Arc Welded Compound Branch Connection for Heating System

We put the standard of welding up rather high, and in breaking in new men keep after them until they show a marked improvement in their welding before we expect any footage from them.

We generally inspect our welds by the depth of the crater and the discoloring of the metal caused by the heat of the weld on the opposite side of the weld, as well as the appearance of the weld.

Fig. 9—Fan Shells Made from 3/16-In. Tank Steel to Replace Heavy Castings. The Heavy Rings Are Welded to the Shell and Machined after Welding

We use a ⅛-in. electrode for No. 14 gage, 5/32-in. for No. 12 and No. 10, and 3/16-in. for 3/16-in. gage.

The amount of amperes, or heat, as we term it, is governed by the welder himself. We generally use around 125 amperes for No. 10 gage, where the joints fit fairly close together on a butt joint.

Plan to Attend Annual Meeting American Welding Society to be held in New York, April 22 to 24.

Twelve important papers will be presented including a number of important phases of welding. There will also be reports on research work, codes, and an inspection trip.

Something special in the way of entertainment is being prepared in connection with the annual dinner of the American Welding Society.

Economics of Welding in Maintenance and Operation of Gas Transmission Systems

By ERICK LARSON

✦ This paper was prepared by Erick Larson, Superintendent of Gas Distribution, Long Island Lighting Company, Bay Shore, N. Y., and presented before the Annual Convention of the International Acetylene Assn., Chicago, Nov. 1930.

THE facts and opinions on the art of welding as brought out in the following articles are the result of an intensive study of some typical transmission and distribution systems of the East. They are from the viewpoint of the operating executive rather than from that of the technical expert. Much of the material herein contained is similar to that included in the "Empire Gas and Electric Association's Gas Distribution Committee Report to the 1930 Gas Section Convention Held at Elmira, N. Y." This report was composed by the writer for the committee.

As a result of the extensive discussion as to what constitutes an acceptably tight distribution system, it was decided to investigate (1) the causes of leakage in a line and (2) whether it would pay to repair the slightest leaks. Since the most interesting results were found to be in connection with the uses of steel pipe and with the advantages of welding pipe lines, this report will be limited to these two factors.

Use of Steel Pipe

Steel pipe sections were selected for several reasons. In the first place they are generally used throughout the country. Also many companies are being forced to change from their all cast-iron policy to wrought iron or steel because of the modern high-pressure systems now being installed. And finally, the uses and features of cast iron are common knowledge, while steel still requires educating the public to its advantages. Steel piping is nothing new in certain classes of industry, for it has been in use for many years in the oil fields.

At present practically all steel pipe used in gas lines is of lap- or butt-welded, longitudinal seam type. Because of this, split seams and porous or laminated pipes are of relatively common occurrence. However, the manufacture of seamless tubing is rapidly developing to the point where its higher cost does not overbalance its advantages. As its application is extended, undoubtedly the price level will be brought down more nearly to that of the longitudinal seam type. Nevertheless, the present existing difference in price between the seamless and other types of pipe calls for study in order to determine which is the more economical.

Leakage

Tests made by the Bureau of Mines on numerous pipe lines indicate that the least leakage may be expected from a properly constructed welded steel pipe line. The question arises as to why there should be any leakage in a line in which every joint has been tested and the type of construction is such that the line is one continuous length of pipe.

Many times cheapness of construction leads to the use of unsuitable joints, when a more thorough study of leakage and maintenance costs would have revealed no economy in the long run. We are too prone to accept the word of some designer or operating engineer that his type of joint never fails. But the main foreman repairs many leaks about which the manager never hears. It is far better to conduct some research and study as did the Bureau of Mines when they advocated welded steel piping.

Welding

Welding has been more or less limited to the oxy-acetylene process because of the greater experience available in its use.

In the field of oxy-acetylene welding the scientific thought and effort put forth not only in original development, but also in the perfection of a procedure control is an example for any industry to follow. It is the direct reason for its success. Firms manufacturing welding equipment employ corps of engineers not only for the purpose of instructing new welders but also for the solution of unusual problems and for the continued study of the science of welding. However, it still remains necessary for the local manager and engineer to have a thorough knowledge of the science of welding so that the proper principles may be passed on to those doing the actual work. Furthermore, the high morale necessary in the actual welder and his immediate superiors must be properly understood. The human factor plays an important part in welding; and a welder regularly instructed and encouraged pays dividends.

Stresses

For all the excellent theoretical work that has been done in the computation of the internal stresses of lines placed underground, nothing as yet has exceeded experience. Both standard and light weight steel pipe have been laid under many conditions carrying gas and hydrostatic pressures that bring the internal stress of the pipe to within 75 per cent of its elastic limit. After years of service in the southwest such pipe lines have yet to develop any trouble in the pipe itself. While such a close margin of reserve strength is not to be recommended, still it does indicate that theoretical computations must be tempered with experience. There never has come to the attention of the writer a single instance of a circumferential break in a steel pipe except at points of weakness where threads and grooves are cut into the pipe for certain types of couplings. This fact indicates that a more thorough theoretical knowledge of stresses entering into pipe line construction may lead to considerable saving by cutting down wall thicknesses. Since temperature and line pressure stresses lend themselves to mathematical exactness, some of the more intangible factors found will be enumerated.

One of the largest stresses to which any pipe may be subjected is that due to temperature changes, a large proportion of which arises at the time of laying. On a hot sunny day in New York State actual tests have shown the not uncommon temperature of 110 deg. F. of the pipe itself, while the ground temperature at a depth of 2½ ft. is but 60 deg. F. Proper laying will overcome most of the stresses resulting

from such abrupt temperature changes, however. If the burying of the pipe proceeds from one end only, and the end toward which the burying proceeds is free, natural contraction will be taken up by movement of the free end of the pipe. This overcomes stresses which in a pipe rigidly fastened at both ends would have to be taken up internally. In the March 9, 1929, issue of *Gas Age-Record* was an article entitled; "Ground Temperatures Obtained at Varying Depths at Schenectady, N. Y." In a summary the following results were shown:

Maximum Ground Temperatures

5 ft. Cover	August	57 Deg. F.
3 ft. 6 in. Cover	July, August	59 Deg. F.
2 ft. Cover	July	66 Deg. F.

Minimum Ground Temperatures

5 ft. Cover	March	23 Deg. F.
3 ft. 6 in. Cover	January, February, March	22 Deg. F.
2 ft. Cover	February	14 Deg. F.

From the standpoint of strength, this survey would indicate that burying to a depth of only 2 ft. would be

Fig. 1—Oxy-acetylene Welding Gas Transmission Line

an economically sound proposition. The added stress caused by the difference between 22 deg. and 14 deg. F. is only 1560 lb. per square inch. This stress is based upon a modulus of elasticity of 30,000,000 and a coefficient of expansion of 0.0000065. Taking the maximum differential and using the same factors, the stress due to the difference in temperature between seams would be 10,140 lb. per square inch. For still greater extremes, let us assume a differential temperature of 100 deg. maximum in order to allow for poor conditions at the time of laying. The temperature stress would then be 19,500 lb. per square inch. Taking a gas pressure of 60 lb. per square inch, a pipe diameter of 6 in., and a pipe wall thickness of ¼ in., the stress from this source would be 720 lb. per square inch. In the Southwest pressures as high as 350 lb. per square inch are being carried in standard weight pipe lines. The stress due to gas pressure is at right angles to the temperature stress. The resultant stress, which is 10,000 lb. per square inch under the elastic limit of steel still leaves some margin to take care of the stresses of unknown magnitude caused by the motion of the earth from the frost action, loads imposed vertically over the main of sufficient intensity to cause the main to act as a beam, and bending during laying. Practice has proved that this margin of safety is sufficient.

From this study it must not be assumed that it is recommended to bury a pipe to a depth of 2 ft. Other factors enter that again show the necessity for study beyond actual design and construction. Where gas is pumped for more than a mile, actual field tests have proved that there is practically no difference between the ground and gas temperatures. In most plants the gas sent out is corrected to the standard condition of 60 deg. F. However, the Schenectady survey shows the ground temperature over a period of several months of the year to be at an average of 20 deg. F. As a result of this 40 deg. difference between send-out temperature and sales temperature, there is an 8 per cent loss in the quantity of gas delivered which is shown up as unaccounted for gas. The above survey indicates that the temperature would be above 60 deg. at the 2-ft. level for only a period of two months during the year. During these two months the average temperature would be about 62 deg. F. A similar study in the southern part of the State over a period of two years gave a maximum temperature average of 66 deg. and a minimum of 42 deg. at the 2-ft. level, for the temperature of gas in the main. These figures were taken at a distance of 4½ miles from the plant. Simultaneously, a test determined that the gas a mile from the plant was at ground temperature.

The use of any type of so-called expansion joint to take care of temperature changes has not been mentioned for two reasons. In the first place it was desired to show extreme conditions. Furthermore, a study of lateral movement of buried pipe in the ground, as reported in a booklet entitled, "Controlling Temperature and Bending Strains in Bronze-Welded Cast Iron Pipe Lines," by E. Hering, F. G. Outcalt and T. W. Greene, published by The Linde Air Products Company, proves that an expansion joint is not as effective as is generally supposed in relieving temperature stresses even as close as 100 ft. from the joint because of the high frictional grip of the soil.

Testing

Studies and tests which have been made show why there is some leakage in a welded steel line even though every joint has been given a soapsuds test. As a result, it is recommended that tests should not be limited to joints alone, but that methods of detecting other leaks should also be employed. All sections, where possible should be tested above ground by means of a soapsuds test of the joints and a closed-in pressure drop test of at least three hours to indicate any major leaks. The coating should then be applied and the pressure drop test repeated in the trench before burying. After burying at least a 24-hour drop test should be made. The slightest indication of a drop in pressure should be the signal for a test lasting until it is determined that the drop is not due to temperature changes or to a leak at the cock where air is pumped into the main. In case of a drop, the section should be divided into convenient lengths, and tests should be applied to each. As the sections become shorter, the leakage becomes more noticeable, so that when the trouble is located and the pipe dug up, the actual leaking piece of pipe can be repaired or replaced. If the leak is caused by a split seam, it can be welded in place; but usually it will pay to remove the section as the part repaired may not be the only leak. The argument that this large expense is

not warranted when the small amount of leakage is considered may be answered by considering the sum total of the leakage loss and by the danger of subsequent property damage suits where shrubbery and trees are apt to be injured.

The advantages of complete welding and careful testing have been clearly shown on one system of over 600 miles of distribution mains. Work done has involved gas welding of all mains since 1926, and all services since 1927; including some replacements and the welding of about 10 miles of pipe originally screw coupled. Property damage of shrubbery and trees on new work has been eliminated. Although the system has been increased 25 per cent in extent during that time, the actual volume of unaccounted-for gas has been cut 37.5 per cent. Whenever a leak has been found on any type of coupling, the repair has been a solid welded job.

The following is a summary of results obtained through the study of the uses of steel pipe:

The use of standard weights and sizes of pipe is recommended.

The placing of light weight sections in a variety of

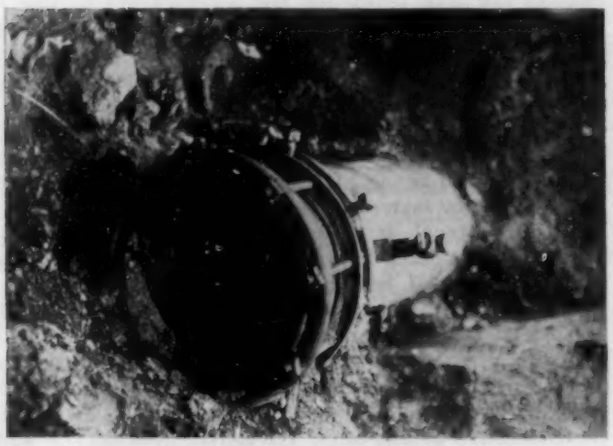


Fig. 2—Line Sealed for Test

conditions and locations is desirable for securing test data.

At present standard weight lines are carrying pressures as high as 350 lb. per square inch.

From strictly the viewpoint of strength the depth of burial of line is not a major factor with steel pipe under temperature conditions prevalent in New York State.

Where care is taken to secure a joint equivalent in strength to that of the pipe, expansion joints are unnecessary.

Lap-welded pipe is preferable to butt-welded, and seamless is preferable to both.

Thorough testing of lines after joining is recommended, including the pipe itself.

Oxy-Acetylene Welding

Oxy-acetylene welding was known experimentally for many years previous to its practical use. Gas welding secured international fame through its use at the Panama Pacific Exposition and through the medium of an artitcle entitled, "Welding in Gas Distribution," in the Gas Industry Magazine, September, 1915, by Mr. D. E. Keppelman of the Pacific Gas and Electric Company. Because of the far-sightedness of the engineers of the Pacific organization, this article is actually history written years in advance. The article is a milestone in the history of welding.

Records show that in 1911 the Philadelphia and Suburban Gas Company laid an 11-mile line south of Philadelphia. From then until 1919 there was a steady increase in the number of companies using the process. In 1919-1920 another milestone was reached. The Prairie Pipe Line Company welded 15 miles of 8-in. oil line to carry 700 lb. pressure. This was engineered by Mr. Noah Wagner, Superintendent of Welding. In 1922, the same company, thoroughly convinced of the advantages of gas welding, laid the longest all-welded line up to that time. It was 104 miles in length. Since then the practice of welding oil and gas lines has become standard practice.

Advantages

It would appear that little need be said of the advantages of welding, but during the past year a number of requests have been made for such information. In general it might be said that there is no limit to welding, since it is used from the largest undertakings to that of the solitary blacksmith in his little shop. However, there are numerous outstanding advantages of oxy-acetylene welding in pipe line construction.

In the first place specials may be made up in the field to fit exactly. Tie-ins with existing piping may be made without cutting the old lines or without the use of expensive and clumsy clamps. This applies to inside as well as outside work. For example: welding is a time saver in the placing of an aquastat or pressurestat during the installation of gas house heating units. A short nipple is welded on the take-off lines near the boiler without necessitating cutting of the line or chancing breakage of the plugs in the boilers. Other applications may be found on large water heating jobs, house heating jobs, difficult house lines and meter headers, intricate bends in main work, and many places where problems arise in which a welded joint proves to be the difference between profit and loss.

Architects are rapidly realizing that the greater ease in detailing a welded rather than a fitted job is sufficient reason to specify welding. Not only are the fittings or pieces required cut to a minimum for the estimator, but also the time required in the field for the checking and reporting of inventory is lessened.

The welded joint is the lightest type of joint for steel pipe. Welding eliminates the necessity of ordering an extra heavy or an upset end in order to allow for structural weakening from the threading. On large jobs the lowering of freight and transportation costs due to the lighter weight results in considerable savings.

Type of joints that are threaded or require a depression being turned in the pipe cause a weakening at that point. Practically no type of joint will give the uniformity of strength possible with welded joints under all conditions.

The use of other than welded joints is sometimes specified for long transmission lines for the reason of the greater speed with which the line may be laid. However, the use of a greater number of gangs in laying pipe will overcome this difficulty. In fact, the installation of distribution mains, services and detail work, together with much of the larger interior work will average less time with welding than with screw joints. This is true because the welder is not held up while pipe is being threaded. If it is not possible for him to con-

tinue his work in the direction he started, he can easily go to the other end of the line or to some other point. This eliminates much work in the final tie-ins. When these tie-ins are made, a slight or even noticeable misalignment offers no particular difficulty.

There is no hold-up in work while waiting for regular or special tools, since the number of tools required is a minimum.

The better conditions under which the tie-in gangs can proceed is also a great time saver. Several sections can be welded in convenient places, put in position, and then welded together in the trench or on a scaffold. The saving in time that results greatly lessens the cost of scaffolding and bell holes.

Changes and additions to a present pipe line system are also simplified by oxy-acetylene welding. A regular pipe fitter usually dislikes to reconstruct or add to an old layout. When the cutting torch and the welding blowpipe are used changes are more easily and more cheaply made.

Whether the pipe is to be covered with a regular

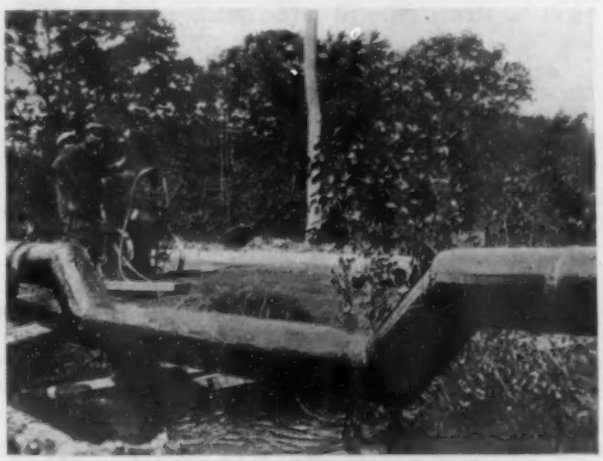


Fig. 3—Offset in Oxy-acetylene Welded Gas Line

steam pipe insulating covering or just painted, the absence of any type of fitting makes the job less expensive. Also, the finished work is neater in appearance.

Actual tests run by the Bureau of Mines prove that in a welded line the flow of water and gases more nearly approaches theoretical perfection than with any other type of joint.

With welding the material transported by the pipe will have no more effect on the joint than on the pipe itself. Other forces such as expansion and contraction, vibration, chemical properties of the soil, strains left in laying or produced by settlement of the trench, earth movements and changes of pressure carried, leave no worries as to how the joint will act. With changing characteristics of gas loads, the fact that pressure conditions can be altered is a factor of major importance and one that is resulting in high pressure distribution even in cities.

In all but welded joint lines, leakage will naturally increase with age and pressure. If there are any existing leaks in the welded line the leakage will increase in proportion to the pressure carried in a manner similar to that of an orifice. In the case of mechanical joints, the leakage will increase considerably in excess of that from a straight orifice because the tendency of the pressure will be to open up the joint. Certain types of rubber or composition packed joints are designed on the theory that added gas pressure will force the packing still tighter against the walls. Tests have proved that the mechanical joint lines of this type not only have the leakage increased in greater proportion than on welded lines, but also on tests at a reduced pressure made after the high pressure test, leakage has increased above that originally found at this lower pressure.

The argument is often used that the human factor in the welding of a joint is greater than that in the making of a mechanical joint. A simple test can be made to show that in any mechanical joint this human factor is just as great. A mechanical joint under pressure can be made up to the point where no leakage is indicated either by hand or by light application of a wrench. The ease with which leakage may be overcome in this test clearly indicates what may happen on a carefully inspected job that has been in the ground for only a short time. The forces to which a line is subjected will soon discover the weak point. While this is by no means a condemnation of mechanical joints, still it is a reminder that even a machine must have a human operator. The severe handling that a welded line receives before it is finally buried, without, of course, deliberately straining it, is one of its best tests.

Welding has gone through its development period in the past twenty years. It cannot be said to be perfect. Comparatively speaking, it has reached a state of perfection that is envious in the realm of joints. Our aim is to have each joint approach or equal the perfection that we know is possible. There are ways and means of securing the desired results that engineering ability and considerable field experience have shown to be possible.

Proposed Specifications for Fusion Welding

✦ Based on proposed specifications for fusion welding of unfired pressure vessels published in the January, 1931, issue of the Journal of the A. W. S., and proposed specifications for fusion welding of drums or shells of power boilers, published in the March, 1930 issue of Journal of the A. W. S.

THE following proposed revisions, which are now under the joint consideration of the American Welding Society and the Boiler Code Committee, are for embodiment in the Code for Unfired Pressure Vessels and for embodiment in the Code for Power Boilers.

The Boiler Code Committee invites communications from those who approve the specifications, as well as from those who wish to suggest changes. Communications should reach the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., not later than April 6, 1931, in order that they may be presented to the Committee for consideration.

Proposed Revisions and Additions to Code for Unfired Pressure Vessels for Fusion-Welded Construction

Pressure vessels may be fabricated by means of fusion welding provided the construction is in accordance with the requirements for material and design as required by this Code and the fusion welding process used conforms to the specifications for the grade of welding indicated for each class of vessel.

Fusion-welded pressure vessels shall be classified according to the following schedule. The grade of welding required for each class shall be as indicated.

Class 1. All vessels covered by this Code, constructed in accordance with the rules for this class, may be used for any purpose. This class includes vessels containing noxious, poisonous or inflammable liquids or gases. These vessels shall be welded with Grade A welding. The allowable working stress shall be 18 per cent (⅕ of 90 per cent) of the minimum of the specified tensile range of the plate used.

Class 2. All vessels covered by this Code are included in this class, excepting those containing noxious or poisonous gases or liquids, provided the plate thickness does not exceed 1¼ in. These vessels may be welded with either Grade B or Grade C welding. When Grade B welding is used, the allowable stress shall be 16 per cent (⅕ of 80 per cent) of the minimum of the specified tensile range of the plate used. When Grade C welding is used, the allowable stress shall be 14 per cent (⅕ of 70 per cent) of the minimum of the specified tensile range of the plate used.

Class 3. All vesse'ls covered by this Code not exceeding ⅜ in. plate thickness and used for the storage of gases or liquids at temperatures not exceeding their boiling temperature at atmospheric pressure, may be included in this class, except those containing noxious, poisonous, or inflammable liquids or gases. These vessels may be welded with Grade D welding. The allowable working stress shall be 12 per cent (⅕ of 60 per cent) of the minimum of the specified tensile range of the plate used for butt joints and 10 per cent (⅕ of 50 per cent) for double-fillet-welded lap joints.

The allowable working stresses on the joints in pounds per square inch for different temperatures are given in Table 1.

NOTE: It does not follow that any vessel in which the plate thickness does not exceed ⅜ in. necessarily falls in Class 3, since if welded with Grade A welding it would fall in Class 1, and if welded with Grade B or C welding it would fall in Class 2.

The above classification gives the general features governing the classes into which the various vessels will be placed. The Boiler Code Committee will prepare a list indicating the classes into which the vessels for various uses shall be grouped. It is proposed to stamp each vessel to designate its class and the grade of welding used.

Plate Material. The materials used in the fabrication of any fusion-welded pressure vessel covered by this Code shall conform to Specifications S-1 for Steel Boiler Plate and S-2 for Steel Plates of Flange Quality for Forge Welding, of Section II (1930 Edition) of the Code.

Longitudinal Joints. Longitudinal joints on Class 1 and Class 2 vessels shall be of the butt type and shall be reinforced at the center of the weld on each side of the plate in accordance with Par. U-71. This reinforcement may be machined off, if so desired. The longitudinal joints of Class 3 may be of the butt or lap type. If of the lap type the throat dimension of each of the two welds shall not be less than $\frac{5}{8}T$, where T represents the thickness of the plate. Both edges of the lap shall be welded and the overlap of the plate shall not be less than $4T$.

Circular Joints. Circular joints on Class 1 and Class 2 vessels shall be of the butt type and shall conform to the requirements for longitudinal joints. Circular joints on Class 3 vessels may be of the butt or lap type, either of which shall conform to the requirements for longitudinal joints.

Dished Heads. Dished heads concave to the pressure when used on Class 3 vessels may be inserted in shells with a driving fit and fillet welded inside and outside, except that on vessels 20 in. in. diameter or less the heads may be welded on the outside only.

Qualified Welders. All welding on vessels covered by this Code shall be done by "qualified welders." A "qualified welder" is one who has demonstrated his ability to produce welds which will meet the required tests for the grade of welding for which he is to qualify.

Each qualified welder shall be assigned by the manufacturer an identifying number, letter, or symbol which shall be stamped on all vessels adjacent to and at intervals of not more than 3 ft. along the welds which he makes either by hand or by machine.

The manufacturer shall maintain a record of the qualified welders in his employ, showing the date and result of the qualification tests and the identification mark assigned to each. These records shall be accessible to the inspector at all times.

A welder's qualification shall be effective for a period of 6 months only, at the end of which time a repetition of the qualification tests shall be made.

Stress Relieving. All Class 1 fusion-welded vessels shall be stress relieved. Class 2 fusion-welded vessels shall be stress relieved in accordance with the following:

Longitudinal welds shall be stress relieved where the wall thickness is greater than 0.55 in. and the shell diameter less than 20 in.

Transverse or girth welds shall be stress relieved where the wall thickness is greater than 0.7 in. and the shell diameter less than 40 in.

For other wall thicknesses and shell diameters, stress relieving shall be required for all welds where the ratio of the diameter to the cube of the shell thickness is less than 118.

Where stress relieving is required, it shall be done in accordance with the rules given in Par. 4 of the Proposed Specifications for Fusion Welding of Unfired Pressure Vessels published in the January, 1931, issue of the *Journal of the A. W. S.*

Holes. No unreinforced holes shall be located in a welded joint. When an unreinforced hole in the plate is located near a welded joint, the minimum distance between the edge of a hole and the edge of a joint shall be equal to the thickness of the plate when the plate thickness is from 1 in. to 2 in. With plates less than 1 in. thick, this minimum distance shall be 1 in. With plates over 2 in. in thickness, the minimum distance shall be 2 in.

TABLE I.—ALLOWABLE STRESSES AT DIFFERENT TEMPERATURES FOR THE THREE CLASSES OF VESSELS AND FOR THE FOUR GRADES OF WELDING FOR STEEL SHELL PLATES COVERED BY THE SPECIFICATIONS

Class	Grade of welding	Longitudinal joint efficiency, per Cent	Minimum tensile strength, lb. per sq. in.	Temperature, Degrees Fahrenheit 60	650	700	750	800	850	900	950
1	A	90	55,000	9900	9900	9900	9000	7200	6100	4950	3600
			50,000	9000	9000	9000	8200	6600	5450	4350	3250
			45,000	8100	8100	8100	7400	5900	4900	3900	2900
2	B	80	55,000	8800	8800	8800	8000	6400	5400	4400	3200
			50,000	8000	8000	8000	7300	5800	4850	3850	2900
			45,000	7200	7200	7200	6550	5250	4350	3450	2550
	C	70	55,000	7700	7700	7700	7000	5600	4750	3850	2800
			50,000	7000	7000	7000	6350	5100	4250	3400	2500
			45,000	6300	6300	6300	5700	4550	3800	3000	2300
	D Butt-welded joints	60	55,000	6600*	....	....	....	....	....	....	....
			50,000	6000*	....	....	....	....	....	....	....
			45,000	5400*	....	....	....	....	....	....	....
	D Lap-welded joints	50	55,000	5500*	....	....	....	....	....	....	....
			50,000	5000*	....	....	....	....	....	....	....
			45,000	4500*	....	....	....	....	....	....	....

* These values may be employed for all conditions for which Class 3 vessels may be used.

Inspection. An inspector may designate stages of the work at which he wishes to inspect the welded joints of a Class 1 vessel, and the manufacturer shall either submit the drum for inspection in such partly

completed condition, or as an alternative he may permit the inspector to witness stages of the welding operation at such times as the inspector may select.

NOTE: The X-ray examination required for the joints for Class 1 vessels provides a greater safeguard than any shop inspection.

Class 2 pressure vessels shall be inspected at least twice, and every Class 3 pressure vessel shall be inspected at least once, during construction.

For Class 2 vessels the first inspection shall be made during the welding of the longitudinal joint. At this time the inspector shall inspect the plate material and the fit-up of the work, and observe the workmen to see that only qualified welders are employed on the work of welding. A second inspection shall be made during the welding of the circumferential joints. At this time the inspector shall check any new material being used which may not have been examined at the time of the first inspection, also the fit-up of the vessel at this stage of construction and again observe the welding operators to see that only qualified welders are employed on the work of welding.

For Class 3 vessels one inspection shall be made during the welding of the longitudinal joint. At this time the inspector shall check the plate material and the fit-up of the work, and observe the workmen to see that only qualified welders are employed on the welding work.

Every pressure vessel covered by this Code shall be inspected while under the hydrostatic-pressure test.

The manufacturer shall certify that only qualified welders, as designated by their qualification symbols, have been employed on the work of welding.

Hydrostatic and Hammer Tests. All fusion-welded pressure vessels which are not stress relieved shall be subjected to a hydrostatic pressure of sufficient intensity to stress the longitudinal welded joints to 1½ times the maximum allowable working stress for the grade of welding used in the tank in question, and while subject to this hydrostatic pressure a thorough hammer test shall be applied. This test shall consist of striking the sheet on both sides of the welded joint a sharp blow with a long-handled hammer which shall be 10 per cent of the weight of 1 sq. ft. of the wall of the vessel and not less than 2 lb. The blows shall be struck 2 to 3 in. apart along the joints, as rapidly as a man can conveniently strike a sharp, swinging blow, and as hard as can be struck without indenting the metal of the sheet. After the hammer test, the pressure shall be raised to a point which will stress the longitudinal joint to 2¼ times the maximum allowable working stress, and held at this pressure for three minutes.

All vessels which have been stress relieved shall be subjected to a hydrostatic pressure of sufficient intensity to stress the longitudinal joints to 2¼ times the maximum allowable working stress, and held at this pressure for three minutes.

Specifications for the Various Grades of Welding

Grade A Welding. The specifications for Grade A welding shall be the Proposed Specifications for Fusion Welding of Unfired Pressure Vessels as published in the January, 1931, issue of the *Journal of the A. W. S.*, with the exception that Par. 8, Impact Tests, is to be omitted and Pars. 12, Hydrostatic and Hammer Tests, 13, Holes, and 14, Allowable Working Stresses, are to be revised as herein set forth.

Grade B Welding. The requirements for Grade B welding are the same as for Grade A, except that no X-ray tests are required for the joints of the completed vessels, stress relieving is not required in all cases, and the ductility requirement by the free-bend-test method is reduced from 30 to 20 per cent.

Prior to, but not exceeding six months, before beginning the construction of vessels with Grade B welding as covered by this Code, the manufacturer shall have tested samples of welding of the thickness of plate used in the vessels which he is to build in order to qualify the process which he employs. The requirements for these qualification tests shall include an X-ray examination of the welds, as well as the other tests designated for Grade A welding.

Grade C Welding. This applies to welding that must of necessity be done in other than a horizontal position. The requirements are as given for Grade B welding, except that the samples shall be welded in the position encountered in the manufacture of the vessel and the required ductility by the free-bend-test method is reduced from 20 to 12 per cent.

Grade D Welding. Prior to the construction of any vessels covered by this Code requiring Grade D welding, the manufacturer shall have tested samples of welding of plates approximately ¼ in. and ⅜ in. thick in order to qualify the process which he employs. The test specimens shall be the same as for Grade A welding and shall meet the following requirements:

Tensile Test: The ultimate tensile strength shall not be less than the minimum of the range stamped on the plate.

Ductility Test: The percentage of ductility as shown by the free bend test shall not be less than 10 per cent.

Proposed Specifications for Fusion Welding of Drums or Shells of Power Boilers

It is proposed to make the Proposed Specifications for Fusion Welding of Drums or Shells of Power Boilers, as published in the March, 1930, issue of the *Journal of A. W. S.*, conform with those published in the January, 1931, issue of the *Journal of the A. W. S.* under the heading of "Proposed Specifications for Fusion Welding of Unfired Pressure Vessels," except in the following particulars:

Par. 8—Impact Tests. Omit.

Par. 12.—Hydrostatic and Hammer Tests. Change to read as follows:

Hydrostatic Test. The vessel shall be subjected to a hydrostatic pressure of sufficient intensity to stress the longitudinal joints to 2¼ times the maximum allowable stress, and held at this pressure for three minutes.

Par. 13.—Holes. Change to read as follows:

Holes. No unreinforced holes shall be located in a welded joint. When an unreinforced hole in the plate is located near a welded joint, the minimum distance between the edge of a hole and the edge of a joint shall be equal to the thickness of the plate when the plate thickness is from 1 to 2 in. With plates less than 1 in. thick, this minimum distance shall be 1 in. With plates over 2 in. in thickness, the minimum distance shall be 2 in.

Par. 16—Add a new paragraph to read as follows:

Inspection. An inspector may designate stages of the work at which he wishes to inspect the welded joints of a vessel, and the manufacturer shall either submit the drum for inspection in such partly completed condition, or as an alternative he may permit the inspector to witness stages of the welding operation at such times as the inspector may select.

NOTE: The X-ray examination provides a greater safeguard than any shop inspection.

British Practice in the Welding of Monel Metal and Pure Malleable Nickel

By N. C. MARPLES, M.Sc.

✦ Mr. Marples is head of the Technical Service Section, Monel-Weir, Ltd., Catheart, Glasgow.

THE rapidly extending use of monel metal in practically every industry, and of pure nickel for many types of apparatus in the Dairy and Food Industries, renders some consideration of the welding methods applicable to these materials of general interest.

Monel metal is, of course, a copper nickel alloy of high nickel content, containing about two-thirds nickel and one-third copper, associated with approximately 3 per cent of other metals in carefully controlled amounts. In appearance it resembles silver and behaves chemically in a very similar manner to pure nickel, while being at the same time stronger, tougher and cheaper than the latter.

From the standpoint of the welder the practice to be followed with monel metal applies also with nickel, which in the recognized malleable forms is of over 99 per cent purity.

Note.—While this article deals with welding and welding methods, it must be noted that both Monel Metal and Pure Nickel can be soft soldered, silver soldered or brazed just as readily as copper, employing the same methods and fluxes.

Welding Methods: On account of the difficulty of fluxing off the oxide film which forms at a welding heat, neither monel metal nor pure nickel can be satisfactorily "fire welded" in the manner followed with mild steel or wrought iron. Both metals can, however, be welded quite readily by the oxy-acetylene process and also by the various electrical methods (these including carbon and metallic arc welding, resistance welding, butt welding, spot welding and seam welding) provided the working conditions are adjusted to suit the metal.[1]

Choice of the Method: For general work the methods most commonly adopted are:

(a) oxy-acetylene welding
(b) Metallic arc welding.

Additional to these, electric spot welding and electric seam welding have proved very satisfactory for particular purposes, while for such parts as chain links, electric butt welding has given excellent results.

In regard to this latter it should be noted, however, that chain links, made by chisel pointing the

[1] American practice in the welding of these metals is covered in the Working Instructions of the International Nickel Co., and the paper "Production of Ductile Welds in Nickel and Monel Metal." N. B. Pilling and T. E. Kihlgren, Trans. Am. Welding Soc., April, 1929.

WELDING METHODS FOR MONEL METAL AND PURE NICKEL SHEETS
Their Applicability in Reference to Thickness

Thickness			ELECTRIC WELDS				OXY-ACETYLENE WELDS			
							Butt Welds		Edge Welds	
			Figs. 2 d and 2 f				Fig. 2 a–c	Fig. 2 d	Fig. 2 e	Fig. 2 f
Gauge No.	Dec. Inches	Millimeters (approx.)	Metallic Arc	Carbon Arc	Spot Weld	Seam Weld	Flanged to 75°	Plain Butt Weld Edges Chamfered 45°	Flanged at 45° and Flanges Butted	Sheets Placed Edge to Edge
26	0.018	0.47	X	C	B	A	A	X	A	C
23	0.024	0.61	X	C	B	A	A	X	A	C
21	0.032	0.81	X	C	B	A	A	C	A	C
20	0.036	0.91	X	C	B	A	A	C	A	C
18	0.048	1.22	X	C	B	A	A	C	C	A
16	0.064	1.62	X	C	B	C	X	A	C	A
14	0.080	2.03	C	C	B	X	X	A	X	A
12	0.104	2.60	C	C	B	X	X	A	X	A
1/8"	0.125	3.2	A	C	B	X	X	A	X	A
3/16"	0.187	4.8	A	C	B	X	X	A	X	A
1/4"	0.250	6.35	A	C	B	X	X	A	X	A
1/2"	0.50	12.70	A	C	X	X	X	A	X	A

Fig. 1

ends before butting, are regularly welded both by the metallic arc and oxy-acetylene processes with complete success.

As the fabrication of apparatus from sheet is the most common application of welding, the table in Fig. 1 will give a useful guide as to the choice of the method for such work. In this table the relative suitability of the various methods in relation to the thickness of metal is indicated by the letters A, B, C and x, the significance of these letters being as follows:

A = Good method easily applied.
B = Method can be used easily in special cases.
C = Method can be used, but with some difficulty, where other methods are rejected for special reasons.
x = Method impracticable for this thickness.

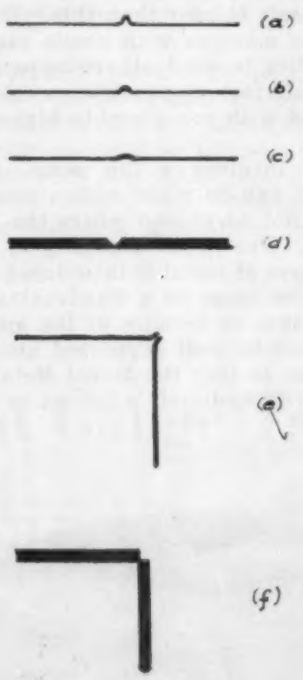


Fig. 2

WELDING PRACTICE

Note.—While Monel metal is specifically mentioned, the same methods hold good for Pure Nickel.

Oxy-Acetylene Welding: This being the method most usually adopted for general work it will be described first:

The Gas Supply: Either acetylene from a generator or dissolved acetylene can be used. As, however, the prime essential for the oxy-acetylene welding of monel metal is a flame which is just on the reducing side of neutral, an even gas pressure is of great importance, particularly for light work. On this account separate cylinders of dissolved acetylene for each worker are preferable, since where several torches are served by a ring main from a common generator, the fluctuations in pressure caused by large burners cutting in and out make the control of the flame for light work distinctly difficult.

Size of Burner: The size of burner selected for welding Monel Metal Sheet of any particular thickness should, in general, be one size larger than the burner recommended for the welding of mild steel of the same thickness. This is necessary since as a reducing flame is employed, considerably less heat is developed for any particular size of burner than would be the case if that size of burner were operating with the usual neutral flame employed in mild steel welding.

Oxygen Control: On the top of the oxygen cylinder it is usual to have a diaphragm reducing valve by which the pressure of the oxygen supplied to the burner can be varied between zero and approximately 25 lb. per sq. in. The author has found that it is of the greatest importance that this diaphragm valve be set correctly to correspond with the thickness of metal which is being welded. Some welders are apt to argue that they have complete control of the oxygen supply to the burner by means of the valve on the torch. While this is true to some extent, there is always the danger that a very slight modification of the valve on the torch will have a very big influence on the nature of the flame if there is a heavy pressure behind the valve. Consequently, for the welding of sheet say 16 i.s.w.g. thick, it is recommended that the pressure at the diaphragm reducing valve be cut down to approximately 8 lb. per sq. in. and to 5 lb. per sq. in. for 26 i.s.w.g. To attempt to work these thin gages

Fig. 3—20′-0″ x 5′-0″ Ebbulition Chamber for Caustic Soda Plant. Chamber Constructed of ¼″ Thick Pure Nickel Sheet with Welded Joints

with a valve set at 20 lb. per sq. in. is bound to lead to trouble sooner or later.

Setting of the Flame: Supposing the flame to have been set neutral, as if for welding mild steel, then the correct "reducing" flame for Monel Metal is obtained by gradually closing the oxygen valve on the burner until on examining the flame through blue glasses a small lilac colored flame can be seen to dart in and out of the inner blue cone. Once this is seen to be occurring regularly it may be taken that the flame is correctly set for welding Monel Metal.

Fluxes: The most satisfactory flux for oxy-acetylene welding Monel Metal is ordinary Powdered Boric Acid (not Borax). This Boric Acid may be applied simply by sprinkling it on the part to be welded, or alternately may be made up into the form of a saturated solution in alcohol. In this latter form it can be applied to the parts to be welded with a soft brush; the alcohol then rapidly evaporates, leaving a thin film of Boric Acid on the metal.

The Use of the Filler Rod: For flat butt welds on Monel Metal Sheet thinner than 18 i.s.w.g. it is usual to avoid the employment of a filler rod, the weld being made simply by flanging up the edges of the sheet to a height of about 3/32 in. and butting the two flanges together (see Fig 2a). This flanging should be done carefully and the flanges left so that they are slightly inclined to each other—i.e., the flanged edge is only turned up about 75 deg., *not*

90 deg. These two flanges are then fused down into the body of the sheet by the application of the torch (Fig. 2b). On this thickness of work the ridge left after welding should be hammered down flat (Fig. 2c). For sheets thicker than 18 i.s.w.g. the edges of the sheet should be chamfered at an angle of 45 deg. (Fig. 2d), and a filler rod coated by dipping it into a saturated solution of Boric Acid in alcohol should be applied. The diameter of the filler rod should be the same as the thickness of the sheet.

For corner welds on sheets thinner than 18 i.s.w.g. the edges should be flanged up at 45 deg. and the flanged parts butted together (Fig. 2e), afterwards fusing down in the same manner as for flat butt welds —Figs. 2a and 2b; heavier than 18 i.s.w.g. the sheets are butted edge to edge at right angles to each other

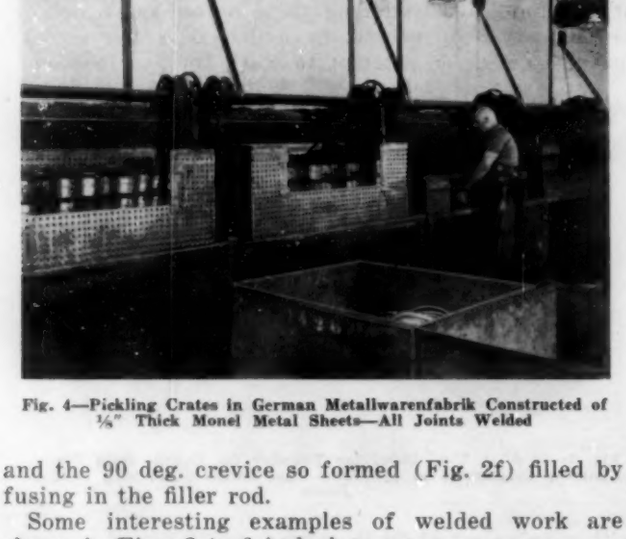


Fig. 4—Pickling Crates in German Metallwarenfabrik Constructed of ¼" Thick Monel Metal Sheets—All Joints Welded

and the 90 deg. crevice so formed (Fig. 2f) filled by fusing in the filler rod.

Some interesting examples of welded work are shown in Figs. 3 to 6 inclusive.

Metallic Arc Welding: There are two main essentials for Metallic Arc Welding of Monel Metal and Pure Nickel:

(1) Reversal of polarity, i.e., the work should be negative instead of positive.
(2) A satisfactory deoxidizer and flux coating on the electrode.

The flux used must possess certain definite characteristics, including:

(a) Good deoxidizing qualities.
(b) Good fluxing qualities for any oxide formed.
(c) Good slag forming qualities—the slag to float readily to the top of the metal and protect it from oxidation during solidification.

Such a flux coating is that prepared and applied to Monel Metal Rods by Messrs. Alloy Welding Processes, Limited. This flux coating is clean to work with and fulfills the above requirements very satisfactorily. In addition it adheres tightly to the Monel Metal wire, enabling the latter to be bent and handled without the coating becoming detached.

Apart from the foregoing requirements the practice in Metallic Arc welding Monel Metal and Nickel is practically identical with that for steel welding, and no further comment is therefore necessary.

Electric Spot Welding: Monel Metal or Pure Nickel can be successfully spot welded on most of the spot welding machines that are on the market, though care is necessary to prevent burning of the metal. In spot welding care must be taken that the pressure is on the metal before the current is passed through the work. Should there be an air gap between the metal and the electrode of the machine, the material will not be welded throughout, but merely stuck together, and can be broken very easily. Spot welding can be done with water flowing over the electrode. This prevents or minimizes oxidation at the weld.

Automatic Electric Seam Welding: There are available on the market today several seam welding machines designed to make a continuous spot weld, and these can be used successfully on Monel Metal. The practical limit for electric seam welds on Monel Metal is 18 i.s.w.g., the method being unsuitable for sheets thicker than this. It is essential, however, that a machine with ample capacity in the secondary winding be used, otherwise penetration will not be good. Satisfactory penetration on Monel Metal is only obtained with considerably higher amperages than with steel.

The method involves a lap seam, and whereas fairly neat jobs can be made with a seam weld, this method should not be chosen where the best appearance is desired. Due to the necessity of using a lap, a double thickness of metal is introduced at the seam. This may in some cases be a disadvantage either for mechanical reasons or because of the appearance.

The work must be well supported under the seam welding machine so that the Monel Metal at the line of the weld and immediately adjacent to it cannot be

Fig. 5—Pure Nickel Five-Compartment Milk Storage Tank

bent during the time the weld is made and until the metal has cooled down below 400 deg. C. Any movement of the metal at a red heat will weaken it, and even if fractures do not appear at once, the probable result will be cracks occurring along the line of the weld after the job is in service.

For seam welding, as for all types of spot or butt welding, the metal must be perfectly clean. Water flowing over the electrodes at point of contact reduces oxidation at the welds.

CORROSION RESISTANCE OF WELDS ON MONEL METAL AND PURE NICKEL

One of the outstanding advantages of welded construction on Monel Metal and Pure Nickel is that the corrosion resistance of the weld, if carefully made, is practically as good as that of the metal itself.

An interesting instance of this is afforded by the Pickling Crates illustrated in Fig. 4. This shows a number of Monel Metal crates built from ⅛-in. thick Monel Metal sheet with oxy-acetylene welded joints. These crates were put into service over three years ago and are continuously employed for pickling steel parts in either 10 per cent Sulphuric Acid or 25 per cent Hydrochloric Acid. Despite these severe corrosive conditions the welds, after over three years' service, are practically unaffected.

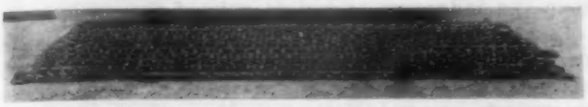


Fig. 6—Welded Monel Metal Link Chains for Acid Pickling Service

Another important feature of welded joints on Monel Metal and Nickel is that the exposure of the metal to welding heat does not induce that unpleasant phenomenon now so familiar to those who have attempted to construct apparatus from the Austenitic Nickel Chromium Steels, i.e., "weld decay." Consequently the troublesome and often impossible heat treatment necessary with these latter materials, if "weld decay" is to be avoided, is not in any way necessary with Monel Metal or Pure Nickel.

PRODUCTION OF MACHINABLE WELDS ON CAST IRON

No paper which deals with the welding of Monel Metal would be complete if it did not make some mention of the valuable qualities of Monel Metal as a welding material for damaged iron castings. Monel Metal is being increasingly employed for this purpose and has the advantage that the welds produced on iron castings with Monel Metal Electrodes are quite readily machinable. This, of course, is contrary to the results obtained when steel or iron electrodes are employed.

Welds on cast iron, employing Monel Metal Rod, may be made either by the electric or oxy-acetylene process, the former being, however, preferable, since the heat is much more localized and pre-heating of the castings to avoid cracking is therefore unnecessary.

For satisfactory results to be obtained, the Monel Metal Wire should have a good deoxidizer and flux coating.

Light Gauge Tanks

✦ Actions taken by Boiler Code Committee, A.S.M.E., on Inquiries and Investigations on Light Gauge Tanks. (A series of investigations conducted by the Joint Pressure Vessel Committee of the A.B.W. and A.S.M.E. were reported in the February, 1931 issue of the Journal of the American Welding Society).

CASE NO. 677

Inquiry: May the longitudinal seams of tanks for the storage of air or water under pressure at not to exceed 150 lb. per sq. in. be made under the rules of the Code for Unfired Pressure Vessels by using the electrical, resistance, compression, butt weld method? This process of welding involves bringing the two edges of the sheet together at one point and applying locally and continuously a current of sufficient intensity to bring the edges to the welding temperature, and while the heated section is in a plastic condition, compressing the edges together so as to obtain thorough union thereof.

Reply: It is the opinion of the Committee that although this method of welding is not provided for in the Code, it may be used with safe results provided the material and construction of the tank come within the requirements of the Code, and provided:

That the plate used for tanks for the purposes described and for this method of welding shall conform to Specifications S-2 for Steel Plates of Flange Quality for Forge Welding;

That this method be limited to the use of plate not over 0.135 in. thick;

That prior to the welding operation the edges of the plate and the electrical contact area shall be cleaned so as to free those surfaces from all scale, oxides or grease;

That the weld be made progressively and continuously over its entire length;

That the offset of the edges due to the compressing shall not exceed 60 per cent of the thickness of the plate;

That the prescribed tests for the hydrostatic pressure as specified in the Code are complied with;

That the unit stress shall not exceed 8000 lb. per sq. in.

A revision of the Code to cover the above is under consideration.

CASE NO. 678

3139—For the same reason as cited in Case No. 677, an interpretation was formulated to cover the question of the insertion of dished heads which was raised by the John Wood Manufacturing Company, as follows:

Inquiry: May the heads of tanks for the storage of air or water under pressure not to exceed 150 lb. per sq. in. be inserted into the ends of the cylindrical shell, either concave or convex to pressure, and secured by fusing the edges of the shell to the head or the edges of the shell and head flange, under the rules of the Code?

Reply: It is the opinion of the Committee that although this method of construction is not provided for in the Code, if the shell plate does not exceed 0.135 in. in thickness and heads do not exceed 0.15 in. in thickness, tanks for the purpose described with heads inserted in the ends of the shells, either concave or convex to pressure, come within the requirements of the Code, provided:

That the heads are designed in accordance with Pars. U-36 to U-39 of the Code;

That the head concave to pressure is inserted so that not more than ½ in. of shell projects beyond the point of tangency of the flange and knuckle before welding, and that the resulting valley is filled in with weld metal formed by fusing the projecting edge of the shell or/and the introduction of extraneous metal;

That the head convex to pressure is inserted so that the edge of the flange is substantially flush with edge of the shell and the two thoroughly fused together, or as shown in Fig. U-7*b*, using fusion welding;

That the prescribed tests for the hydrostatic pressure as specified in the Code are complied with.

A revision of the Code to cover the above is under consideration.

Automatic Arc Welding in the Electrical Industry*

By G. H. KOCH

* This paper was prepared by Mr. G. H. Koch, General Engineer, Westinghouse Electric & Manufacturing Company, and was presented at the Southern District Meeting of A. I. E. E. Louisville, Ky., Nov. 1931.

THE use of arc welding to build up an integral structure from a large number of commercial steel shapes and plate members is one of the recent developments in machine design and construction. The manufacturers of electrical machinery were among the first to take advantage of the flexibility and new design liberties afforded by this method. At present the design of the welded structures is undergoing careful revision to permit the utmost use of the automatic welding head to replace the manual welder in the shop. The additional economy and better control justify a large shop investment of properly selected tools and handling devices.

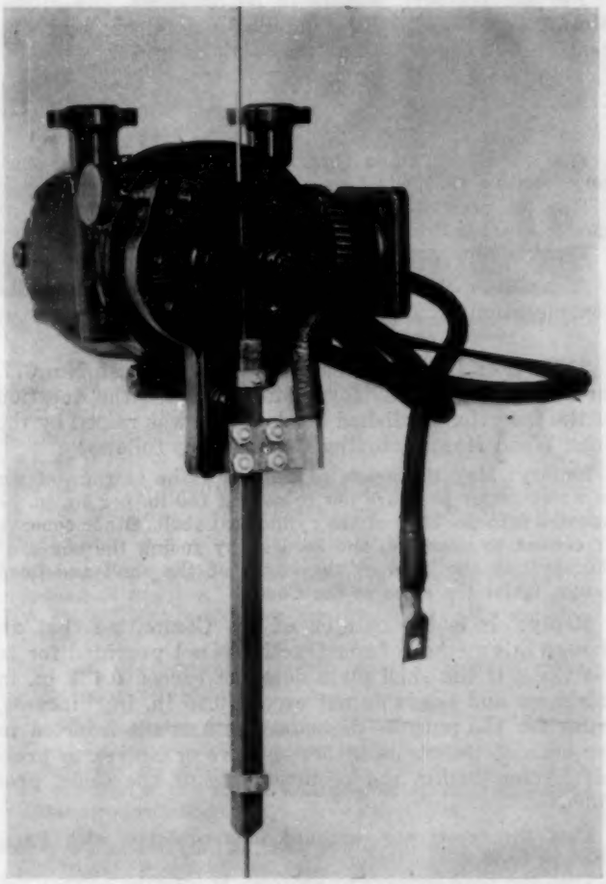


Fig. 1—Westinghouse Automatic Welding Head

Manual Welding

Recent publications have thoroughly discussed the advantages of arc welded products over the structures they have superseded. This applies both to the fabricated machine members replacing castings and to the welded plate and structural members formerly riveted. The change in method of production indicates only the use of a new art to obtain the desired results more economically or with greater satisfaction and dispatch. Where manual welding is employed, the trained welder replaces the trained foundryman or the skilled riveter in obtaining the final results. In both the old and the new process the quality of the product is as much dependent upon the care and vigilance of the artisan in overalls as upon the judgment and slide rule of the designer.

In the performance of his work the experienced manual welder reflects good training and muscular control. With his eye and ear intent upon the arc he imparts several distinct motions to the electrode with accuracy and uniformity thereby obtaining the necessary fusion and electrode deposit. With steady hand and alert eye he corrects any fault in the repeated cycles of the operation. These functions performed by the trained operator are particularly suited to reproduction by machinery. The arc voltage must be maintained at a constant value and the electrode feed toward the arc should be as uniform as is consistent with a constant arc length. The progress of the arc along the seam should be steady and at a fixed rate. These are all simple tasks for the machine but when carried out manually, only a well-trained and skilled operator will produce satisfactory results.

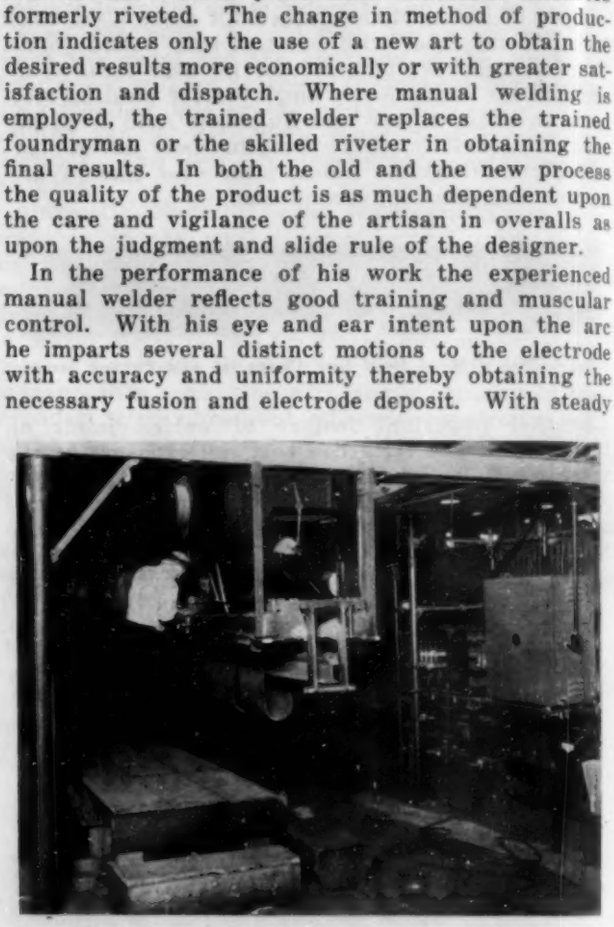


Fig. 2—Automatic Seam Welder for Tank Sheets and Tubes

Automatic Arc Welding

In an automatic arc welding machine an electric motor is used to feed the electrode at the required rate to maintain a constant arc length or voltage between the electrode and the work. Elements sensitive to arc voltage automatically regulate the direction and speed of the electrode to maintain this arc length constant even on an irregular surface. Separate motor driven devices provide a uniform motion of the arc along the seam and a weaving motion across the seam where this is desired. After the current value, arc voltage and travel speed are selected for a given job, the operator is required only to start and stop the welding operation and to change the work. In some high production work even this is done automatically.

Since the conditions at the arc as to speed, current and arc voltage affecting the heat distribution along

the seam remain very constant, the best combination can be worked out and welds of the highest quality can be duplicated without difficulty. The fact that all variables are under control favors increase of welding speed to the limit.

As a general rule only slightly larger electrodes are used for automatic welding than for hand welding on a given job. Increased welding speed is brought about largely by the fact that a higher current density in the electrode is possible than in hand welding because of the shorter current path in the electrode from the holder to the arc. About 25,000 amperes per square inch of electrode section is common in automatic welding compared with 10,000 amperes per square inch in hand welding. This increased current concentration at the arc makes for better fusion and

Fig. 3—Lap Weld Made by Automatic Welding

improved stability. Usually less deposited metal is required in automatic welding because of this factor and because of the greater general reliability. Furthermore, since the electrode is fed continuously from a reel there are no interruptions such as the manual welder introduces in changing electrode rods. All of these factors tend toward increased speed and better welds.

The comparative welding speeds for automatic and manual arc welding are now fairly well known for existing commercial electrodes. In general it may be said that simple continuous welds may be made with an automatic welding head in one-third to one-sixth of the time required by an expert manual welder. The first figure holds for welds on material greater than ¼ in. thickness, whereas the greatest time saving is effected with the thinner sheets.

Fig. 1 shows an automatic welding head ready for welding. The electrode feed is automatically regulated through a motor drive by a control system located in a separate cabinet. The electrode passes through a long nozzle after it leaves the driving rolls and emerges at the lower end to be fused in the arc and deposited on the work. The welding current enters the electrode through the sliding contact in the nozzle.

Applications

One of the earliest applications of automatic welding in the electrical industry was in connection with the repair of steel street car wheels. Because of the sharp curves in the right-of-way there is considerable wear at the flange to change the wheel face contour. The shape of the face must be restored after a limited amount of wear has taken place and unless the worn section is built up by welding an excessive amount of material must be cut from the face of the wheel.

One man can keep the four automatic arcs in operation, thereby doing the work of twelve manual welders. The automatic weld sets up much lower shrinkage stresses in the wheel than a manual operation since a large number of beads are added successively at a relatively high speed, thereby providing a uniform heat distribution.

Automatic welding was next introduced in the manufacture of sheet steel tanks for transformers and circuit breakers. Fig. 2 shows a seam welding clamp used to make longitudinal butt and lap welds in round, elliptical or rectangular tank shells. A large shell or a number of small ones are held against a backing bar by air pressure clamping fingers and the weld is made by the automatic head, which is

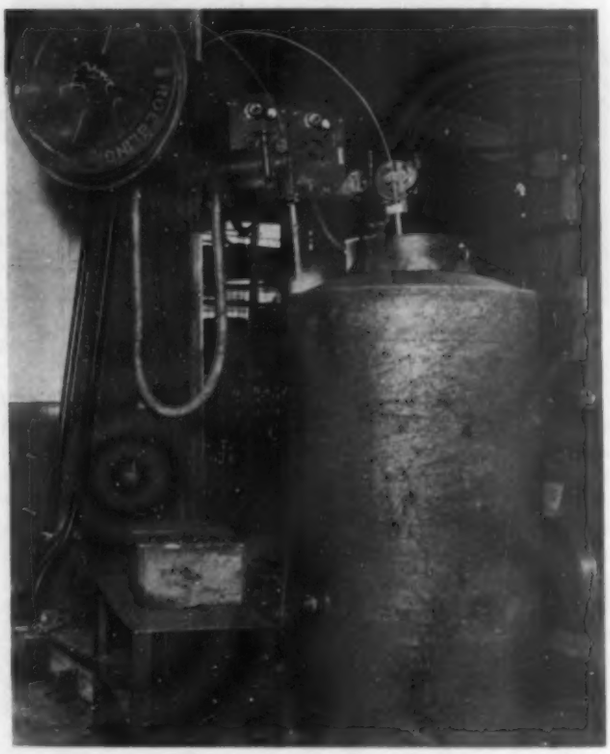


Fig. 4—Two Heads Used Simultaneously in Welding Circuit Breaker Tanks

mounted on the travel carriage. The carriage also mounts the electrode reel and operator's controls and is self-propelled at any desired welding speed on a trackway built integral with the air clamp frame.

An oiltight reenforced butt weld is made on 5/16-in. thickness steel at a rate of 20 ft. per hour without beveling or otherwise preparing the edges. This weld is reenforced on both sides and must pass rigid inspection for appearance as well as for strength and density. For maximum strength and best appearance on heavy sheets such a weld is often made in a number of passes. For instance, with 5/16-in. plate the unprepared edges may be separated ¼ in. and the first weld made at 60 ft. per hour, using 3/16-in. commercial electrode wire and 320 amperes. The second weld is then made at 30 ft. per hour, using the same

electrode but only 190 amperes with a slight oscillation across the seam as the weld progresses. This method insures complete penetration with reenforcement on the under side to conform with a groove in the backing bar. The outside of the weld becomes a flat reenforcement of great strength and good appearance. Welds on other structures of the same plate thickness can often be made at higher speeds, but circuit breaker and transformer tanks require completed seams of the highest quality. A weld as described above cannot be duplicated by an expert manual welder at a speed greater than 6 ft. per hour using commercial electrodes. The comparison shows

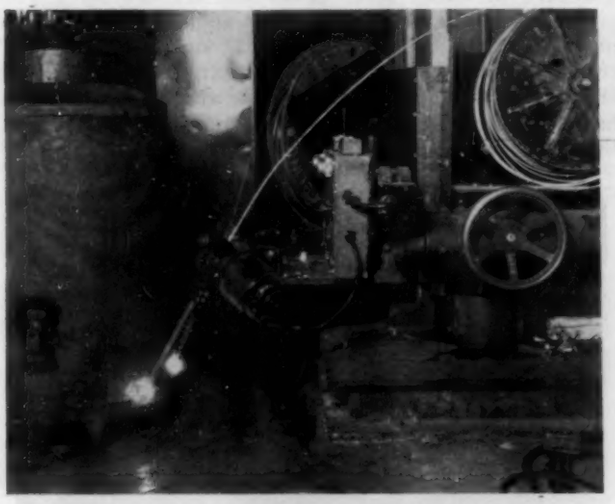


Fig. 5—Small Circuit Breaker Tank During Welding Operation

a time saving of 70 per cent. On lighter plates the saving is still greater. Fig. 3 shows a close-up of a lap weld made on the seam welder with an automatic head.

A method of welding bottoms in cylindrical circuit breaker tanks is illustrated by Fig. 4. The shell is centered on a turntable flush with the floor level and is rotated under the arcs held by the two automatic heads. In this way the bottom of a 42-in. diameter tank with a ⅜-in. wall thickness is welded in 18 min. by a single operator compared with 2½ hr. manual time. Fig. 5 shows the side wall of a smaller tank being welded to a cast steel reenforcing ring on the same machine with the heads lowered on their supporting pedestal to a point near the floor level.

With the recent advent of electrical machinery frames fabricated from structural members and plates welded together to take the place of castings, automatic welding received another impetus. The design of these fabricated frames and structures is now undergoing revision to admit the maximum use of automatic welding. The additional economy, strength and reliability afforded by the automatic operation justifies a large shop investment in tools and handling devices.

Fig. 6. shows a machine especially developed to weld short straight seams. The welding head is mounted on an arm, which reciprocates along the joint at welding speed. The wire reel and operator's control are mounted on the base of the machine so that the entire unit may be moved to a heavy piece of work within the radius of the supply cable reach.

For heavy fillet welding it is necessary to tilt the work to obtain the most satisfactory results. This is especially true of plates greater than 5/16 in. in thickness for a full strength fillet. With one vertical and one horizontal surface for the fillet each deposited bead has a tendency to spread out over the horizontal surface producing a decided overlap together with poor fusion and ragged appearance. A large number of smaller beads at relatively high speed decreases this tendency to overlap, but forms a series of parallel grooves resembling cracks between adjacent beads. Tilting the work is very effective in obtaining a normal fillet such as is produced by an expert hand welder with proper manipulation. With the two surfaces to be joined inclined at 45 deg. to the vertical a trough is formed for the weld metal permitting maximum welding current and metal deposit.

The use of automatic welding is not limited to heavy

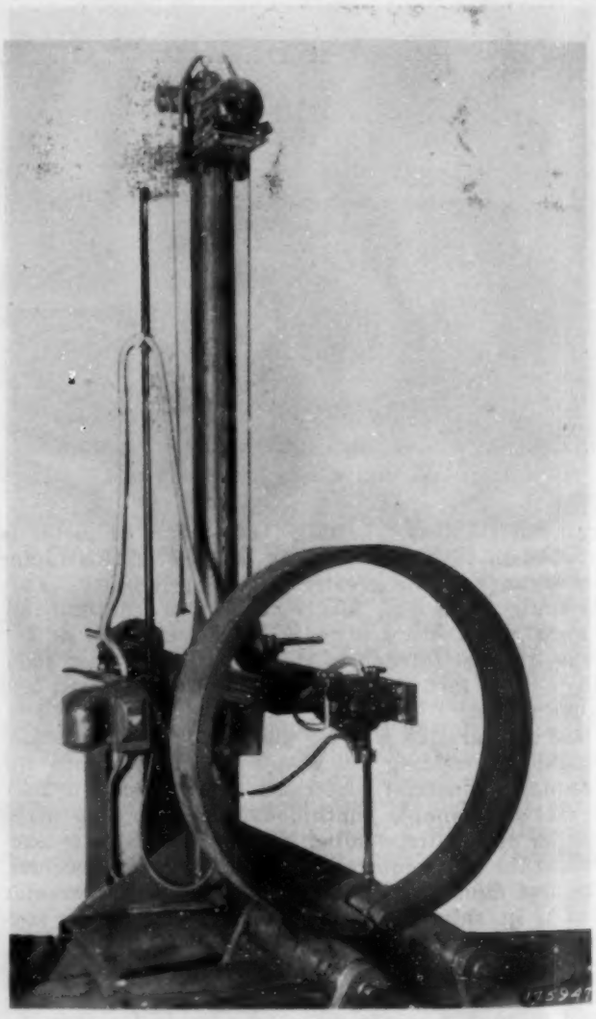


Fig. 6—Machine to Complete a Ring by Automatic Welding

welds on large joints. As a matter of fact, the time saving over manual welding shows up greatest on thin sheets and small beads.

Fig. 7 shows an automatic welding application in the assembly of small safety coil tanks. The work consists of one deep drawn shell with terminal outlets forming the top and sides of the tank. The flanged bottom is pushed into the tank shell and the joint is sealed with a fillet weld. The weld is made after the tank is loaded with its coil parts and filled with in-

sulating gum. A special type of handling machine was developed for this work to provide ease of loading and unloading and adaptability to a range of lengths and diameters. The bed of the machine is mounted on trunnions to permit welding at the most desirable angle and to present either end of the tank to the arc without inverting the tank. The driving

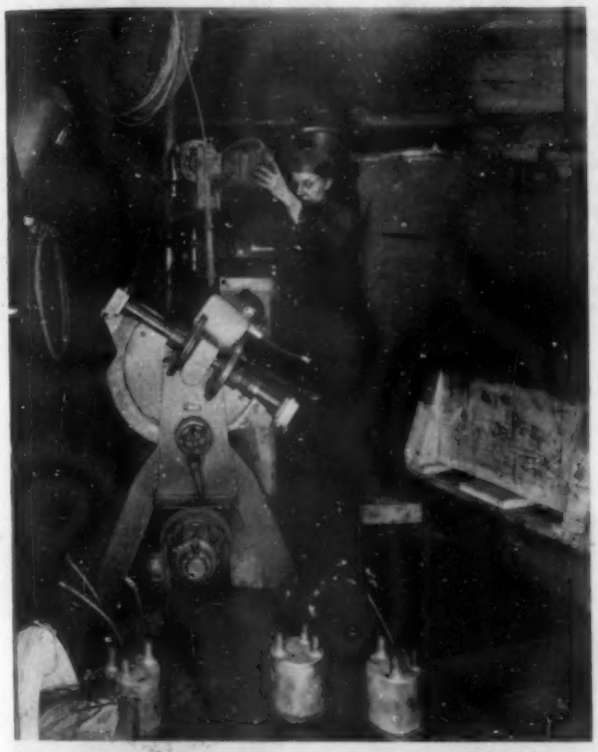


Fig. 7—Manufacture of Safety Coils by Automatic Welding

element consists of four parallel flanged supporting rollers on two shafts driven by an electric motor through a gear train. By using this driving system it is necessary only to place the cylinder on the rollers to prepare it for the welding operation. The peripheral or welding speed remains the same for all diameters with one adjustment.

This weld is completed in 45 sec. compared with a welding time of 7 min. for the manual operation. A welding current of 140 amperes and ⅛-in. diameter electrode is used to make complete the seam on the No. 14 gage material at a welding speed of 140 ft. per hour. A speed of 2000 ft. per hour would be easily obtainable with increased welding current at a slight sacrifice in appearance.

Possibilities

The saving in welding time effected in each of the applications illustrated in this paper should give a good indication of the possibilities of the automatic welding head in leading the way to new production economies. Provided work handling apparatus is included to limit the handling time in changing the work and provided such apparatus can be installed at reasonable expense nearly every production welding job is open to automatic welding from the economical viewpoint. In some applications where handling time is unavoidably the bulk of the welding time for any process, automatic welding can still be considered for its improved and consistent results.

Success of Oxy-Acetylene Welded Pipe Lines

By G. O. CARTER *and* T. W. GREENE

† This paper was prepared by G. O. Carter, Consulting Engineer and T. W. Greene, Engineer, Development Section, The Linde Air Products Company, New York, and was presented before the Annual Convention of the International Acetylene Assn., Chicago, Nov., 1930.

DURING this year of rather marked industrial depression, particularly in the steel industry, the one outstanding bright spot has been the unprecedented demand for line pipe and the construction of pipe lines. Accompanying this activity, there has, of course, been a very extensive application of oxy-acetylene welding in this industry. This year has witnessed the starting of several of the largest and longest lines in the world and has been accompanied by an extremely broad activity in the welded construction of numerous lines throughout the whole country.

To review adequately the success of oxy-acetylene welding of pipe lines, it is necessary both to review the history of welding and to present the statistical growth of the pipe line industry itself. The construction of pipe lines may be divided into two major divisions of oil and gas; although a third classification of gasoline transmission lines has assumed and promises to become a major field in the future. To date there are approximately 99,000 miles of oil trunk and major gathering lines in the United States. There is, in addition, also about 57,000 miles of natural gas lines. Since the laying of the first high pressure oil line, extending from Cherokee Station, Okla., to Bartlesville to carry 700 lb. pressure, built in 1919-20 by Mr. Noah Wagner, Superintendent of Welding of the Prairie Pipe Line Co., who was awarded the Morehead Medal by this association, the growth and application of oxy-acetylene welding to oil pipe lines has been phenomenal. During the last five years when construction of these lines has been greatly accelerated, welding has been almost exclusively used as standard.

Oil Lines

To illustrate the extent and magnitude of the oil lines even in localized sections of the country, Fig. 1 is presented showing the transmission lines from the Hendricks, Yates and other west Texas pools to refineries in Oklahoma and to Tidewater. From these pools there are ten major systems to date, some of which are looped with three parallel lines, having a capacity of over 300,000 barrels per day. All of these lines are welded and with the exception of one, are oxy-acetylene welded. Extensive as this mileage is, potential capacity of the fields which ultimately must be provided with pipe line facilities, will demand the laying of two and possibly three times the present number of lines.

The whole history of oxy-acetylene welding of oil lines, including as it does literally tens of thousands of miles carrying pressures of 750 lb. and higher, has been exceedingly gratifying. There has rarely, if ever,

been a failure of the joint. In fact, there are several existing systems, involving 3000 miles or more, in which a joint failure has yet to be experienced. Millions of barrels of oil have been and are being transported without the loss of a single barrel. Oxy-acetylene welded joint has indeed proven to be a very economical and thoroughly reliable pipe joint for oil transmission.

Due to the conservation policy in oil production and the proration of the large oil pools, building of long transmission lines this year has been somewhat limited as compared to the last two. There has, of course, been the usual building of short lines and

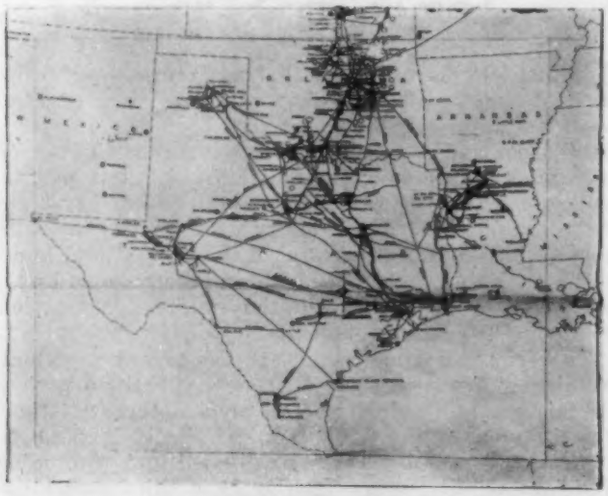


Fig. 1—Oil Pipe Lines from West Texas Pools

gathering and extension of existing oil transportation systems to the new fields, as to Oklahoma City pool and the Hobbs field in northeastern Mexico. There have, however, been two major installations, the Ajax pipe line, a twin or double 10-in. oil line, about 750 miles, running from Oklahoma to St. Louis and the Gulf Company line extending from Oklahoma to Pittsburgh. Oxy-acetylene welding is used exclusively in the former and extensively in the latter.

Gas Lines

The most important activity in the pipe line industry this year has been the phenomenal development and construction of gas lines, to some extent for the transportation of manufactured gas, but principally for the transmission over long distances of natural gas. Only a few years ago the transportation of natural gas, for example 250 miles, was regarded as a wonderful achievement. This year has witnessed the starting of building of enormous lines, 22 in.-24 in. in diameter, running over 1000 miles in length in order to make available to communities in Illinois, Minnesota and Indiana the cheapest and cleanest of fuels produced in the gas field of the Panhandle section of Texas and other mid-continent fields. Three major 24-in. lines have been started from the Panhandle field this year; one of these to the Omaha and south Nebraska regions; another, the Amarillo to Chicago line being built by the Continental Construction Company for the Doherty-Insull interests and other companies, and the third one by the Missouri-Kansas Pipe Line Company to Indianapolis and other towns in Indiana and Kentucky. Oxy-acetylene welding, with the exception of the first one, which was constructed with rubber couplings, has been used extensively in the construction of these large diameter, major projects, the lines being built by what is known as composite construction, in which two to three or more joints are welded together and then coupled.

Oxy-acetylene welding has offered to the gas, as well as to the oil industry, an economical and leak-proof joint that has proved highly satisfactory. Any review of published statistics on leakage will reveal the success of welding in reducing the leakage to a negligible figure; in fact, leakage as low as 10,000 cu. ft. per year per mile per 3-in. equivalent has been accepted as standard, a figure undreamed of before the advent of welding. It has been reported, that leakage tests have actually shown an increase in the gas in the line, although officially it has never been reported where any testing division of an operating department has credited the construction department with creating gas as a result of employing welded construc-

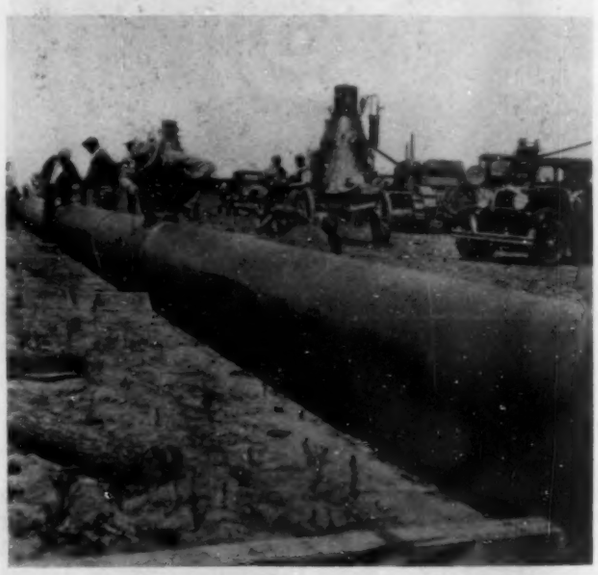


Fig. 2—Oxy-acetylene Welding Large Diameter Transmission Lines

tion. Welding, nevertheless, has forced refinements in metering and measurements.

The more or less standard practice today has been to use solid welded construction for lines smaller than 18 in. Solid welded construction also has been used on larger sizes, as 18 in. and 20 in. Above 20 in. diameter, however, the general practice has been to use composite construction.

Welding Large Diameter Pipe

It is desirable to review some of the reasons why composite construction is used on the larger lines because the solid welding of large diameter presents and necessitates special engineering consideration and construction. Theoretically, the unit stresses set up in a large pipe as a result of temperature drop are the same as for small line, but due to their very nature, there probably is an unequal distribution of the contraction forces in large diameter which impose higher stresses on certain elements than on others. The problem is further complicated by the introduction of differential stresses in a large line during construction. Moreover, it is exceedingly more difficult

to provide adequately the slack in the line required to compensate for contraction. The accompanying figure shows slack wallops in a 24-in. line. The laying of these wallops, which at the best provide for only about half of the contraction requirements, imposes very high stresses, stresses so high, in fact, that failure may occur unless the welding is of the highest quality. These are only temporary and are relieved on lowering the pipe to the bottom of the trench but complicate the laying of the line.

In addition to the temperature stresses, there are super-imposed bending stresses which from the very nature of the line cannot be minimized in the larger diameters. Smaller pipe can be easily cold bent to fit the contour of the ground closely but in the larger diameters this cannot be carried to such accuracy, with the result these strains may become very excessive. Theoretically, for the same deflection the stresses will increase in proportion to the diameter which, although they may be negligible for small diameter, become very high as the pipe sizes increase.

Fig. 3—Making Slack Wallops in 24-In. Overland Line

Fig. 4—How the Liner Is Welded into a Line

These, of course, can be reduced and alleviated by changing the construction from that of a solid continuous tube to that of a series of free length beams, as it were, by the introduction of couplings properly placed. It is for this reason, as well as the simplification in construction that composite construction has been more extensively used in the larger sizes.

There is need for development of more satisfactory procedures and methods in the way of bending the pipe to meet the contour, of providing for expansion-contraction, and of adopting practices that will assure extremely high weld quality to withstand the strains set up on the circumferential joint in the construction and operation of large diameter lines. These features have received careful consideration and engineering thought and procedures have been developed which have proved satisfactorily to meet all requirements. But further thought and time are necessary to put these into general practice and to speed up the construction to prove universally acceptable.

One development has occurred this year which may prove of decided importance in the future construction of large lines. It has been the generally accepted theory of engineers that the maximum length of pipe between rubber couplings should be limited to about 100 ft. in order that the leakage will be minimized at the rubber couplings. This year has seen the establishment of a precedent in which lengths as long as 350 ft. have been solid welded, and it will be interesting to note what effect this will have under operation. Should this prove satisfactory, it will lead to the welding of practically the entire line, taking advantage of leak proof and economical qualities of the welded joint, yet with simplification of construction attending the use of rubber coupled joints at long intervals.

With the transportation of gas enormous distances, economical factors have introduced and necessitated the use of extremely high pressures, which, in turn, have required special high strength pipe. Pipe in large diameters today is being used having a carbon content of .30-.40 per cent and an ultimate strength higher than 80,000 lb. per square inch, even as high as 100,000 lb. The welding industry, fortunately, has kept abreast of this development in materials and due

Fig. 5—Pipe Ready to Be Lowered into Trench

to the improvements in welding and the development of special welding rods, welded joints can be made as strong as the pipe.

The welding of such large diameters and of pipe material of such high strength has necessitated raising the quality of the welding to such an extent that "super-perfect" welding is required to meet the construction and operating services. One outstanding development which is being followed this year to give assured high weld quality is the use of a thin backing up liner to aid in the welding of the pipe joint. These liners are of thin material, about 1/16 in.-3/32 in. thick, depending upon the pipe diameter, and about 1¼ in.-1½ in. wide, which fit the inside of the pipe joint under the butt weld. The liner with the spacers attached to it, accurately governs the spacing and permits the operator to fuse readily for the full wall thickness. In fact, with special design of liner, it is possible to reinforce the inside of the joint, fusing to the liner, making it an integral part of the weld. There are, of course, no protrusions or icicles and yet it is reinforced on the inside to give a full strength joint even without external reinforcement which it fallaciously had been assumed compensated for weakness that often occurred at the bottom of the joint. The liner so snugly fits the inside of the wall that there is little obstruction, if any, to the flow of the

transmitted fluid. On the larger diameters these have proved to be economical and desirable in obtaining the weld quality necessary.

Economy

As stated before, the oxy-acetylene welded joint has been economical. With the development of efficient welders and the welding more on a mass production basis, which the industry has enjoyed, the cost has decreased. The cost today in welding even the large diameters is less than the cost of welding the smaller sizes several years ago. Means of reducing the cost and speeding up the welding have been given careful consideration. Suitable progress has been made along these lines in the way of using larger flames, decreasing the angle of the vee and in keeping the weld as small as possible. Moreover, there has been a decided reduction of the depth of fusion into the sides of the vee, as the practice in the past of melting for quite a distance into the walls of the pipe, carrying a large weld, is somewhat extravagant and costly. Many of these developments place oxy-acetylene welding in a favorable position with competitive processes.

Workmanship in general has shown a decided improvement in the last few years. More and more the companies engaged in welding are closely qualifying and checking the welders and with development of suitable portable testing machines, now available, this type of inspection has proved decidedly advantageous in increasing the quality of the workmanship. The workmanship on some of the larger lines being welded, as a result of this engineering control, is of a quality unbelievable a couple of years ago. In fact, a study of their test results shows that every joint is nearly as perfect as the pipe.

Gasoline Lines

Before concluding, a few words should be said of a new field for oxy-acetylene pipe line welding that offers tremendous possibilities, namely, that of gasoline lines.

The apparent success obtained by the Standard Oil Company of New Jersey in converting their oil line carrying oil eastward to the Atlantic Coast into a gasoline line carrying gasoline westward, has led to some outstanding developments in this field. This year has witnessed the beginning of the construction of three very long gasoline lines; one, the Sun Oil, running from Philadelphia to Pittsburgh, Cleveland and other cities in Ohio; second, the Phillips Petroleum line from Texas to Kansas City and St. Louis, and the Great Lakes Pipe Line of the Continental and Barnsdall companies, a 1300-mile line from Oklahoma refineries to Chicago and the Great Lakes region. All of these lines are oxy-acetylene welded. The engineering features in the construction and operation of these lines offer no special problem and with the proving of the economical factors connected with their use, it is anticipated that a new large field of pipe line construction will be open to carry gasoline to various parts of the country from the refineries of the various companies. Some of these, no doubt, as in the oil transportation, may become large public carrier systems. As the lines are small and particularly adaptable to the oxy-acetylene construction, requiring the adaptability, versatility and reliability characteristic of this process, a promising future is opened up for the use of oxy-acetylene welding in this new field.

Production Welding by Oxy-Acetylene Process

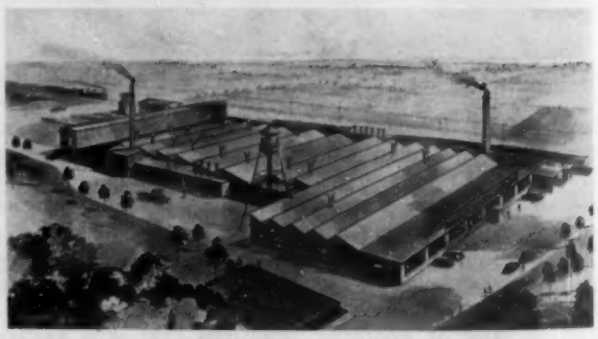
By **E. C. BOOTH**

✦ This paper was read before the 31st annual convention—International Acetylene Association, Chicago, Illinois—November 12-14, 1930. Mr. Booth is Chief Engineer, Noblitt-Sparks Industries, Inc.

WE first entered the manufacturing field with the manufacture of a high-grade automobile hand tire pump in the year of 1919. This pump used tubing which was bought on the outside, was threaded on either end, and screwed into the base and the cap. It was the DeLuxe tire pump of that time. These pumps were sold by special agents to the automobile dealer, and then a little later to the jobbing trade, and quite a business was built up.

Welding of Pumps

But the time soon arrived when we desired to enter the manufacturing field, and with this came the requirements that we make a pump that was not only



Figs. 1 and 2—Views of the Plant, Noblitt-Sparks Industries, Inc., Indianapolis, Ind.

good but would meet the price conditions that we had not met with up to that time.

However, there was one manufacturer who required a pump with a brass barrel, and we developed a self-brazing method of brazing the brass barrel to a steel base, in which we used the oxy-acetylene welding torch to accomplish this result. And then came the development of the steel barreled pump to meet this price condition.

Tubing

We then entered the manufacture of Steel Tubing. We bought sheet stock and sheared it, in the early

stage, on a sheet metal shear. We put these strips through a tuber, forming it into a tube shape in more or less the regular manner that tubes might have been formed up to that time, and we then devised welding machines which had suitable rolls and adjustments, were power driven with oxy-acetylene torch attached and the necessary adjustments for guiding and moving the torch.

The torch condition at this early stage did not give us tubing that was free from skips, blow throughs and misses, but as time went along, the torches were supplied until the time arrived when this condition was practically ended. Further improvements were made in the welding machine and with them came the time when, with a few instructions, a girl could operate one of these machines, and give us a satisfactory tube.

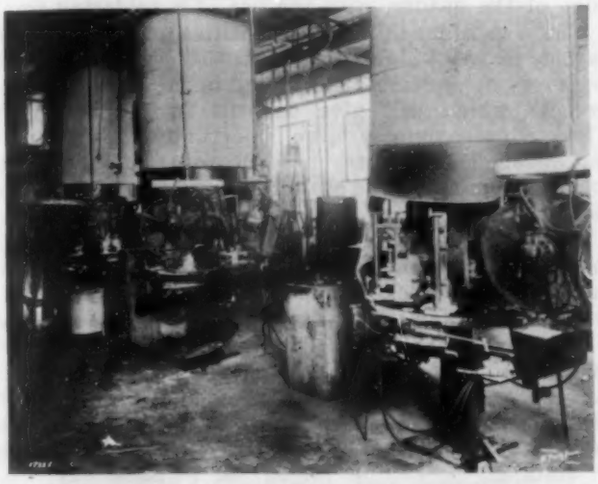


Fig. 3—Semi-Automatic Machines for Bronze-Welding Tire Pumps

Fig. 4—Machines for Welding Tubing

This pump tubing required a weld that needed only a swedging operation which would straighten the tube, and mash down the wrinkles on the inside and outside. In the early stages, this was a double operation in which we used to handle a hard bar, the length of the whole tube and of such a diameter that it could be forced into the tube, and then passed between heavy rollers. The hard bar was withdrawn, and the tube passed through a swedging machine, sizing the diameter and making it straight.

We later developed a new method in which we supported a correct sized arbor in the center of the swedging die in the swedger, leaving only the clearance necessary between the arbor and the swedging dies for the double thickness of the sheet metal used in making the tubing, or the size to which we wanted to reduce the tubing—in case that we wanted to pull it down. This not only smoothed out the wrinkles on the inside and outside, but produced a tube that was straight in one operation. In fact, we got tubing that could hardly be told from seamless. This proved to be a very satisfactory operation, but the swedgers had to be larger than we had used previously.

Special Applications

Then came the time that we looked for an increase in our tubing business, and we began the manufacture of such parts for washing machines and other household utilities. We then desired to enter the bent tubing field, making all types of exhaust and water tubing for the automobile manufacturers. About this same time, one of the large manufacturers just entering the field with a new car, came to us with a great deal of new development in the tubing necessary for the exhaust pipe and muffler tubes.

One tube required a flange that was about 30 per cent larger than the original diameter of the tube. This gave us a welding problem in that the tube must stand this flanging operation as well as stand a small bend. The sheet metal had to have some characteristics that would stand this flanging, bending and welding. Another interesting development in this flanging operation was the devising of a method that would heat the end of the tube approximately $\frac{3}{8}$ in. back to a temperature that was a correct temperature for flanging. If the tube were heated too hot, the metal would break at some point other than at the weld, and if the temperature was too cold, the weld would break. So it was necessary to keep a temperature between these two points. This flange was not only thrown out at an angle of 45 deg. but was thinned at the edge at the same time. The machine made for heating the end of the tube was made so that the end of the tube would roll over. A number of oxy-acetylene torch tips were so placed as to give proper results. This new method proved to be a saving over our original outfit which was a special oil furnace with a heavy cast iron plate, and with holes only large enough to slip the tube in and out easily. This old method was expensive, but was not as dependable in that we could not get the same heating results on tubing placed in the various parts of the flame, as well as the tubes themselves would be hotter at some places than in others.

Bending Machinery

In developing bending machinery, we worked out some equipment of our own which gave us a production which ran eight and ten times greater than we would have been able to get with any standard bending machine on the market. This, however, meant that we were subjecting the tubing and welds to far greater strain in forming and bending than we might have subjected the tubing to had we used the older method. Then we went still further in the development of some of the tools for making some of the

larger bends in punch presses which ran this up still further, and still gave us further problems as far as metal forming was concerned, and, at the same time, put somewhat greater strains on the welds. These bending operations were very interesting in the fact that it is generally conceded that any forming operation which is particularly difficult should

Fig. 5—Air Pressure Test for Welded Tube Products

have a longer space of time so that it gives the metal less difficulty in forming.

The tubing manufacture requires our greatest use of carbide and oxygen, which amounts to approximately 700,000 cu. ft. of oxygen and some 77 tons of carbide per month. Our tubing production runs to some 80,000 ft. per day. We are able to get around 9 ft., 22 gage tubing, per minute up to 2 ft. per minute on 14 gage tubing.

The oxy-acetylene process was further used in the development of a semi-automatic machine in which we brazed the steel pump tube to a steel base in which we are able to get a production of some 3000 pumps per day, per machine.

A still further use of the oxy-acetylene came when we began to manufacture the well-known Arvin Hot-Water Heaters. This requires some brazing, but we depended on oxy-acetylene torches to accomplish our most intricate soldering work—namely, the attaching of the tanks to the headers on the cores, this being a lap joint. The headers and the tanks fit very close together which requires that the solder be run in between the metal, rather than a joint made just at the edge of the header, with the use of a soldering iron.

The use of such large quantities of oxygen and carbide makes it highly important that we look into and try every suggestion and scheme in the oxy-acetylene process which will give us still further economy. There is an extremely large opportunity for engineering developments in torches and torch methods that may be applied to the welding of tubing. This particular field is large.

Developments along most lines are toward sheet metal products, and tubing plays a large part in the make-up of articles, as made today, as against what we were familiar with a few years past.

While we go to great lengths in the developments and devising of schemes and means of making sheet metal working tools, dies, and such, we depend on the oxy-acetylene industry to develop new means and methods necessary to accomplish further economies in welding.

Oxy-Acetylene Welding in Local Gas Transmission and Distribution

By L. A. KIRCH

✦ Abstract of paper by L. A. Kirch of the Midland United Company, Chicago, and presented before the Annual Convention of the International Acetylene Assn.

AT the end of 1924, in our territory there were 480 miles of transmission line, while at the end of 1930 there was approximately 1270 miles in service. Gas service has been made available to 52 villages, towns and cities, having a combined population of 78,430. In addition, the recent success of butane-air gas plants assures gas service to small communities which cannot be economically reached by pipe lines. Very little, if any, steel pipe is being laid without some sort of protective coating. All transmission lines and distribution systems for small new communities are of steel construction.

The above brief synopsis has been given to show the rapid changes which have taken place in the gas industry without the advent or impetus of natural gas. With the possibility of large volumes of natural gas being made available in the future, further development of interconnecting transmission lines and extension of local distribution facilities on a large scale might reasonably be expected.

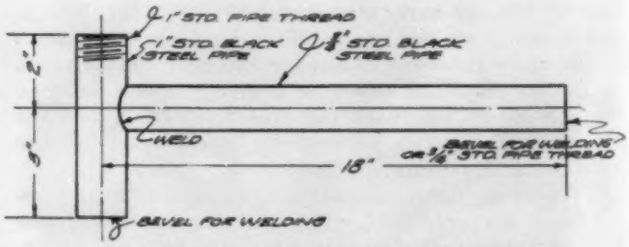
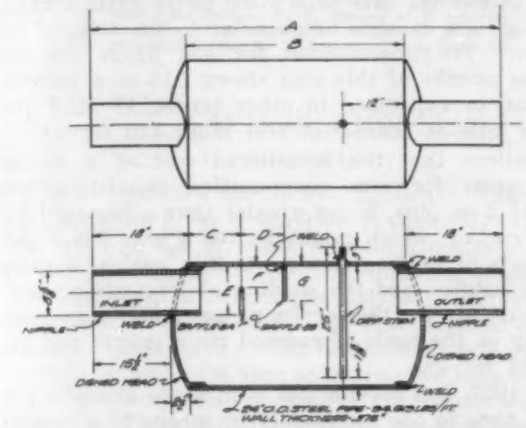


Fig. 1—Service Connection for High Pressure

Welding Organization

Consideration was first given to the use of oxy-acetylene welding in our organization in 1924, in connection with two local feeder mains in two different situations. With the aid and recommendations of service men from a reliable manufacturer of welding materials and equipment, men from our own organization were developed into welders. The single vee type weld was used, and results obtained with reference to initial cost of line and improved construction were entirely satisfactory.

All transmission lines laid since 1924 have been of oxy-acetylene welded joints with the exception of one 26-mile stretch of 4-inch pipe, which was of screw construction. (This pipe was purchased second-hand at a very low price. However, in the light of our present experience, it probably would have been more economical, all factors considered, to have cut off the couplings and welded the joints.) It has been necessary on some of the larger jobs done by our own organization to employ outside welders. The ability of these men with reference to quality and quantity of work must be passed upon by our own welder foreman or inspector. In the case of those lines which have



NOM. DIA. OF LINE	TANK NO.	STD. ITEM NO.	CAPACITY IN GALLONS	A	B	C	D	E	F	G	BAFFLES SPACING A	BAFFLES SPACING B	O.D. OF NIPPLES
4"	4a	3/17550	95	5'0	5'0	8"	6"	5"	2"	4"	6A	4B	4½"
	6a	3/17552	55	3'0	3'0								
6"	6b	3/17554	135	11'0	8'0	8"	6"	7"	3"	5"	6A	6B	6⅝"
	8a	3/17556	80	8'0	5'0								
8"	8b	3/17558	190	11'0	8'0	10"	8"	8½"	4"	6½"	8A	8B	8⅝"
	10a	3/17560	90	8'0	5'0								
10"	10b	3/17562	215	11'0	8'0	10"	8"	12"	5"	5"	10A	10B	10¾"
	10c	3/17564	145	8'0	6'0								

* CAPACITY UP TO BOTTOM OF INLET AND OUTLET NIPPLES.
LONGITUDINAL WELD OF TANK TO BE ON TOP.
ALL JOINTS ARE TO BE WELDED.
FOR TYPICAL INSTALLATION SEE SC-1515

Fig. 2—Assembly of Tank Drips, 24-In. O. D. Tank—for 4 to 10-In. Lines

been laid on a contract basis, no direct supervision is exercised over the welders. However, we have found that reliable and reputable contractors are ready to accept suggestions by our inspector as to improvement in quality of work. In no case have we resorted to cutting out test samples from field welds and testing them in the laboratory. The development of a small portable field testing apparatus, which is now on the market at reasonable cost, may alter our practice in this respect in the future.

Testing

All transmission lines are subjected to air pressure field tests. As work progresses, the line is sectionalized into stretches of approximately one-half mile, and subjected to an air test of 85-100 lb. per sq. in. (the pressure available from the common portable air compressor). Each joint is then carefully gone over with soapy water, in order to locate any frothy or porous welds. An indicating gage is attached to the section under test and must not show a pressure drop after allowing for temperature variations at the beginning and end of the test.

In addition to the sectional tests, a final 24-hr. test is applied to the entire line or to large sections of the line. This test is applied after valves and drips have been installed, and consists of at least a 24-hr. test with a recording pressure gage. The leakage allowed on this test cannot exceed 10,000 cu. ft. per year per mile of equivalent 3-in. pipe.

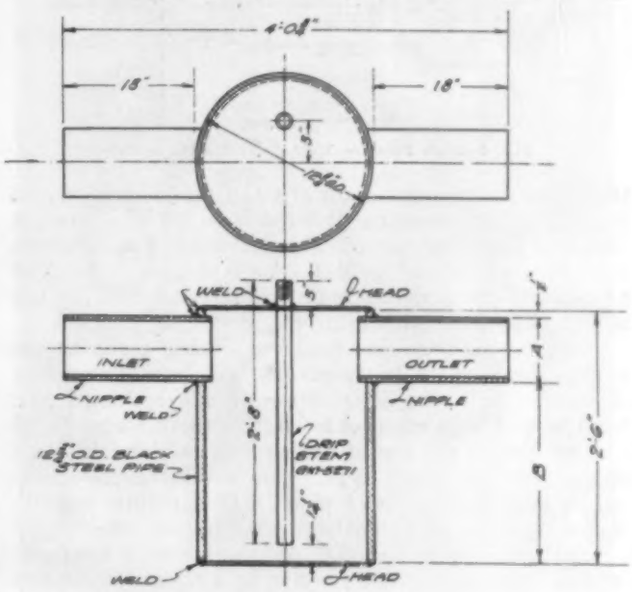
In most cases, the welder is required to stamp his initial or number on the weld, and the weld inspector is given a small bonus for the discovery of pin-hole leaks.

Laying the Pipe

Lines are snaked in the ditch, although no special effort is made to dig a wide ditch. Final tie-in welds, such as those between sections, are made only in the morning when the pipe is relatively cool, or after the pipe has been covered with backfill. At the present time, sleeves are installed on each side of valve installations to avoid strains being placed on the flanges of the semi-steel valves which are being used. This method of installing valves is being given further consideration and study at the present time.

Lap-weld steel pipe, conforming to the American Petroleum Institute specifications, has been primarily used. The wall thickness has been reduced below standard in the majority of cases for pipe 4 in. and larger. In all cases a protective pipe coating is used. A minimum of 15 in. of cover is specified.

The following figures show the total amount of oxy-



NOMINAL SIZE OF MAIN	A	B	CAPACITY IN GALLONS
3"	3½"	20"	12.7
4"	4½"	25"	18.2
6"	6⅝"	22 11/16"	11.2

Fig. 3—Assembly of Steel Pot Drip 12¾-In. O. D. Pot

acetylene welded transmission lines which have been installed since 1924. These figures do not include local feeder and distribution mains:

Size	Miles
2 in.	10
3 in.	32
4 in.	163
6 in.	141
8 in.	60
10 in.	77

A total of three weld breaks—one 6 in., one 8 in. and one 10 in.—has been experienced on the above 483 miles of pipe line. The 10-in. weld which broke was a factory weld used for making 40-ft. length pipe.

Such a record as this would seem to justify our belief that over a period of time a properly welded line will show a very low unaccounted for gas figure and reduced maintenance costs. We also believe that the initial installation cost is equal to or less than that which would be experienced with other types of mechanically coupled joints for the pipe sizes under consideration.

It has been our practice to use steel pipe for low pressure distribution where good soil conditions exist. With the experience obtained on transmission lines,

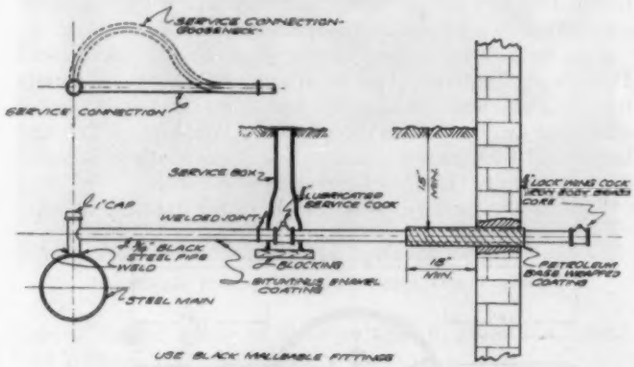


Fig. 4—High Pressure Welded Service Connection

there has been a trend toward the use of the welded joint for low pressure distribution. At the present time, all local low pressure distribution mains where steel is used are of welded construction. A total of 81 miles of low pressure mains, in sizes of 4-12 in., has been laid to date with entirely satisfactory results.

Considerable time and study are being given to the leakage problem in low pressure cast iron systems in connection with the distribution of a dehydrated gas. On new cast iron main construction there seems to be a trend toward the use of the mechanical joint in place of the bell and spigot type. The development of protective coatings for steel pipe is progressing rapidly. Should present differentials in price of steel pipe beveled for welding and cast iron pipe with a mechanical joint continue, will there not be a trend toward the use of welded steel mains with a protective coating for low pressure distribution of gas, even where good soil conditions do not exist?

Service to Consumer

The common method of serving small communities is by means of small steel mains operating at intermediate pressure (2-10 lb.), and individual house regulators which reduce the pressure to that required for appliance operation.

Gas service was furnished to Hobart, Ind., in 1927. In the engineering and design of the distribution system, considerable study was given to initial cost and life of the system, maintenance costs, and unaccounted for gas, with special reference to main and service joints and service connection to the main.

The system, as installed, consisted of 13,300 ft. of 4-in., 7220 ft. of 3-in., and 43,200 ft. of 2-in. oxyacetylene welded steel mains, coated with a coal tar base enamel. All services were welded to the main. Joints for the service run, in addition to the connection to the main, were of welded construction. All services were protected with the same coating which was used on the mains. The entire system was subjected to a rigid air pressure test before being finally placed in service.

Since this was the first system where 2-in. mains and services were of welded construction, special attention has been given to the metering problem. Numerous extensions have been made to the system which have been of a construction similar to the original installation. The unaccounted for gas figure for the first nine months of this year shows 2.15 on a percentage basis, or expressed in other terms, 17 MCF per year per mile of equivalent 3-in. main and service.

We believe that the investment cost of a welded main system for new communities, consisting primarily of 2-in. pipe, is not greater than other methods of construction which might be followed. The slight added costs of welding services to 2-in. mains, in place of using saddles, and the welding of joints in place of screw couplings for the service proper must be justified primarily on the basis of reduced maintenance and unaccounted for gas.

Since 1927, gas service has been made available for the first time to one community by means of a butane-air gas plant, and to 34 communities by means of transmission lines. The total population thus furnished with service, based on 1920 census figures, is 55,812. In all situations, the method of service has been by means of intermediate pressure, welded steel mains, and individual house regulators. No cases of joint failure have been reported.

The preferred method of service installation is by welding. However, we have found that most towns are slow in taking to the use of gas, and that it is doubtful economy to install services to all possible customers at the time the distribution mains are installed. As an illustration, let us take a recent case where a town of 1800 population has just been given gas service. Of the total possible number of customers, approximately 28 per cent are using gas and 35 per cent have signified their intention of using gas within a year's period. Completely welded services, as shown in Fig. 4, were installed for the above 63 per cent. Connections as shown in Fig. 1 were welded to the main for that portion of the remaining potential customers who would not commit themselves favorably to the use of gas at the present time, but who in our opinion would sooner or later become gas users. Such a procedure as just outlined assures a maximum of welded construction with a minimum of cost.

In the local transmission and distribution of gas at either high or low pressures, the original cost of a joint is certainly a very important item. However, the true cost of a joint over the expected life of the pipe can only be determined by taking into consideration maintenance costs and gas leakage.

Strength of Welded Shelf-Angle Connections

By JAMES H. EDWARDS, H. L. WHITTEMORE, *and* A. H. STANG

✦ Mr. Edwards (deceased) was Chief Engineer of the American Bridge Co.; Mr. Whittemore is Chief, Engineering Mechanics Section, U. S. Bureau of Standards; Mr. Stang, Engineer, U. S. Bureau of Standards. This report is also presented in the U. S. Bureau of Standards Journal of Research.

I. INTRODUCTION

1. PRELIMINARY

THE increased use of welding in fabricating steel structures has given rise to many questions regarding the strength of welded connections. In the past most of the tests have been made on relatively small specimens in which the distribution of stress is simple and for which there is an exact method of stress analysis. These have served to establish safe values of stress to be used in design as well as methods of supervision and inspection to insure that good welds are produced. There still remains the need of investigating full-sized connections subjected to the more complex conditions of stress which are present in an actual structure. Definite knowledge of their behavior under load makes it possible to design welded connections which are equally strong in resisting the various conditions of stress to which they may be subjected.

2. PURPOSE

These tests were made to determine the strength of welded connections of the seat-angle type for use in steel-frame building. In this type of connection, angles are welded to the outside of the flanges or to the inside of the flanges of the rolled steel columns as shown at *A* and *C* in Fig. 1. The ends of the beams and girders which carry the floor are supported on these angles. The effect of changing the dimensions of the shelf angles and the location of the welds with respect to the angles were studied.

3. ACKNOWLEDGMENTS

The tests were made at the National Bureau of Standards. The American Bridge Co. furnished the specimens which were designed by James H. Edwards, chief engineer. O. E. Hovey, assistant chief engineer, and other members of the company's engineering staff assisted in making the tests. Prof. Elmer O. Bergman, research associate, made the analysis of the test data and edited the manuscript.

II. SPECIMENS

1. MAKE-UP

A test specimen consisted of a pair of angles welded to opposite faces of an H-section steel column as shown either at *A* or at *C* in Fig. 1. The columns were Carnegie beam sections 3 and 8 ft. long and 10 (CB104) (CB105), 12 (CB126), or 14 (CB146) in. deep. To reduce the number of columns required, two pairs of angles were welded to each column as shown in Fig. 1. As the columns were not, except in a few cases, visibly deformed after the tests, the size of the columns had little effect upon the strength of the shelf angles. As each of the specimens failed through the welds, the properties of the material in the angles did not appear to affect the results of these tests.

According to the manner of attaching the shelf angle to the column, there were two classes of specimens. For class 1, the vertical leg of the angle was placed in contact with the outside of the flange of the column (see *A-A*, Fig. 1) and attached with various combinations of welds as shown for types A, B, C, D, and E (Fig. 2). For class 2, the angle was of such a length that it fitted snugly between the inside faces of the column flanges as shown at *C* (Fig. 1), and type F (Fig. 2), to which it was fastened by a horizontal and a vertical weld at each end. The inner face of the angle, *C* (Fig. 1), was 2 in. from the center line of the web. The distance between the flange of the angle and the web of the column ranged from 1⅛ to 1⅝ in., depending upon the size of the column.

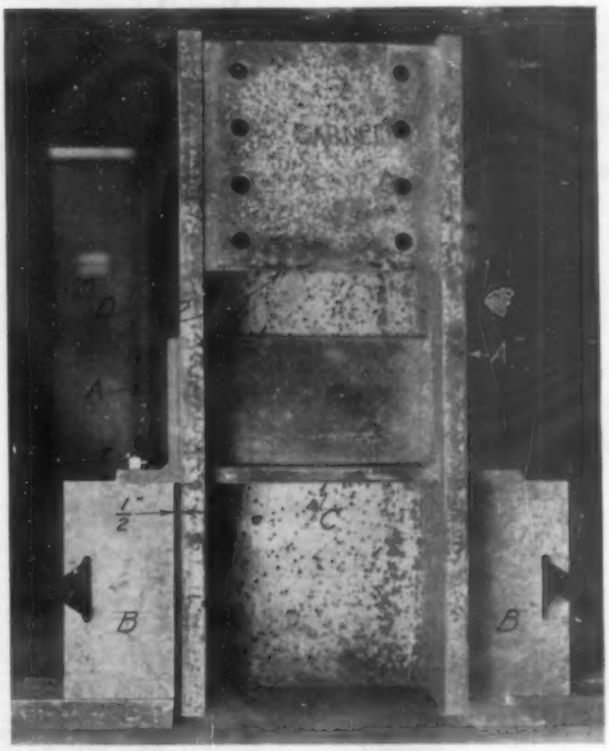


Fig. 1—Column Having Welded Shelf-Angle Connections

Specimen in machine ready for testing. *A-A*, shelf angles welded to the outside of the flange of the H-section. Specimens *A* to *E*, inclusive, were of this type. *B-B*, steel blocks through which the load was applied. As floor beams do not extend over the entire horizontal leg of the angle, spaces were left between the blocks and the column. *C*, shelf angles welded at the ends of the angles to the inside of the flanges of the H-section. Only one is shown as the other angle is on the other side of the column. The distance between the flange and the web ranged from 1⅛ to 1⅝ inches. The steel blocks, *B-B*, were used for loading these angles. They were placed under the entire width of the horizontal legs of the angles. The plate shown at *D* was used in another investigation. (Patent No. 1757859, May 6, 1930, James H. Edwards, "Steel Building, Frame Construction.")

The six types of welds are shown in Fig. 2 and may be described as follows: A, horizontal welds along the heels of the angles; B, horizontal welds along the heels and toes of the angles; C, vertical welds along the ends of the angles; D, welds along the heels and the ends of the angles; E, welds along the heels, toes, and ends of the angles; and F, horizontal and vertical welds at each end of the angles, the angles fitting between and

being welded to the inside faces of the flanges. The number and position of the welds for each type are given in Table 1.

2. WELDS

The welder passed the qualification tests of the Structural Steel Welding Committee, American Bureau of Welding.[1] The welding rod was 3/16 in. in diameter (carbon 0.17 and manganese 0.52 per cent). The arc characteristics were d.c., average amperes 190, average volts 19. The average ultimate strength of all the 20 qualifications specimens was 55,520 lb./in.[2] and the minimum 43,990 lb./in.[2] The average strength of the 12 specimens welded in the horizontal position was 56,990 lb./in.[2] and in the vertical position 53,330 lb./in.[2] The required average was 45,000 lb./in.[2] and the minimum was 40,000 lb./in.[2]

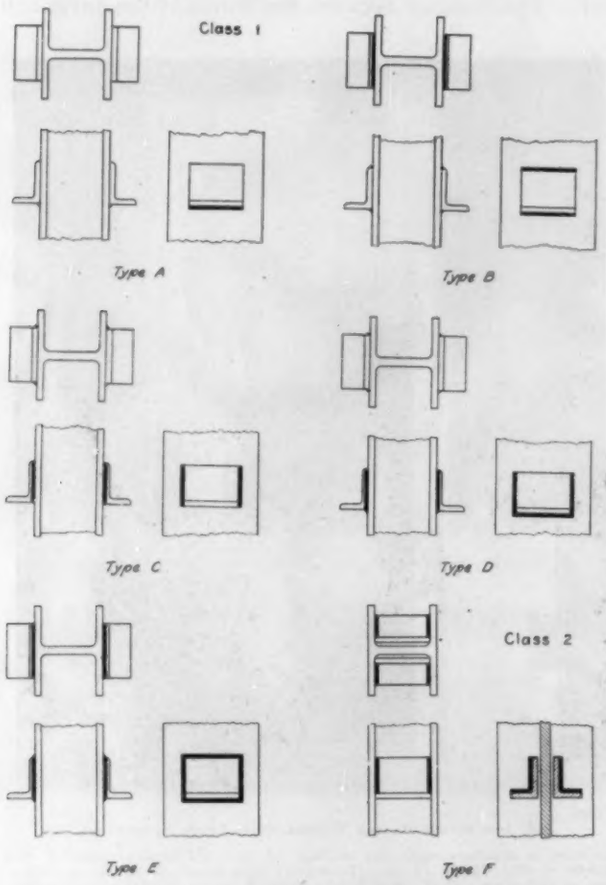


Fig. 2—Drawing of Each of the Six Types of Specimens

All the welds on these specimens were of the fillet type; that is, they were triangular welds, joining two surfaces approximately perpendicular to each other. The nominal size of the welds was 5/16 in., the size of a fillet weld being the designed length of its legs.[2] The actual sizes varied from ¼ in. and 7/16 in. for one weld on specimen F-5 to ½ in. and ⅝ in. for one weld on specimen F-7. They were reinforced so that the actual throat was about equal to the leg of the weld.

The throat of a fillet weld, as defined in the Code for Fusion Welding and Gas Cutting in Building Construction,[3] is the normal distance from the root of the weld to the hypotenuse of the largest isosceles right triangle that can be constructed in the cross section of the fillet weld. The throat of these specimens was computed by multiplying the width of the narrower side of the weld by 0.707. Measurements on many of the welds showed that the actual throat was equal to the shorter leg of the weld.

The lengths of the welds are the corresponding dimensions of the angles. No deductions were made for craters at the ends of the welds.

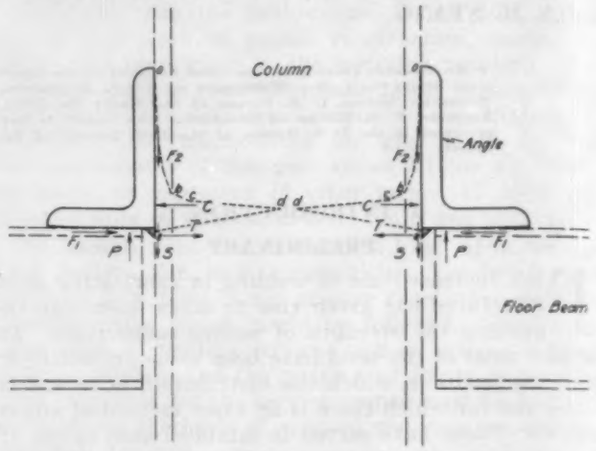


Fig. 3—Free-Body Diagram Showing the Forces Acting on a Shelf Angle and the Weld of a Specimen of Type A Having a Weld at the Heel of the Angle

3. ANGLES

From stock sizes of rolled steel angles, four sizes, having about the same width of horizontal leg, were selected to obtain a considerable difference in the width of the vertical leg. Angles with 4 and 6-in. vertical legs had 4-in. horizontal legs; those with 7 and 8-in. vertical legs had 3½-in. horizontal legs. The angles varied in length from 6 to 12½ in. and in thickness from ½ to 1 in. The dimensions of the angles are given in Table 1.

III. TEST PROCEDURE

The specimens were tested to destruction in the 10,000,000-lb. capacity hydraulic testing machine at the National Bureau of Standards. They were placed in the machine in an inverted position so that the outstanding legs of the angles rested on 6 by 6-in. steel bearing blocks, *B-B* (Fig. 1), placed on the lower platen of the testing machine. This platen is supported by a spherical bearing. After the specimen was placed in the machine, the lower platen was adjusted to bring the upper surface of the column parallel with the upper platen; thus, the applied load was distributed approximately uniformly over the column. In all but two specimens (D-1 and D-2) the angles extended beyond the ends of the blocks. Fig. 1 shows a specimen in the machine ready for testing.

The methods used in loading the specimens were designed to approximate the loading of a similar connection in actual structure. In a structure the load on the shelf angle is the end reaction of the floor beam. To facilitate erection, clearance is provided between the ends of the beam and the faces of the columns. Fig. 1

[1] Specifications for Test Specimens, section B, Qualification of Welders, Part I, Direct Current Metal Arc Process, American Bureau of Welding, 33 West Thirty-ninth Street, New York, N. Y.

[2] Paragraph 75, Weld Size, p. 16, Welding and Cutting Nomenclature, Definitions and Symbols, American Welding Society, 33 West Thirty-ninth Street, New York, N. Y., November, 1929.

[3] Code for Fusion Welding and Gas Cutting in Building Construction, Part A, Structural Steel, Edition 1928, American Welding Society, 33 West Thirty-ninth Street, New York, N. Y.

shows the method used in loading the specimens, having the vertical leg of the angle against the face of the column (types A, B, C, D, and E). The distance between the face of the bearing block and the face of the column was ½ in. so as to load the angle approximately as it would be loaded by a floor beam having clearance at the ends. This method of loading is referred to in this paper as "partial support."

For specimens of type F, having the angles welded at their ends to the inside faces of the column flanges, the supporting blocks were placed under the entire width of the horizontal legs of the angles, because in an actual structure the clearance at the ends of the beam would be less than the distance between the angle and the web of the column. This method of loading is designated "full support."

IV. TEST DATA

The values of the maximum loads and the corresponding values of the maximum loads per unit length of weld and maximum stresses are given in Table 1. In this table the data for each type of specimen are arranged according to the width of the vertical leg of the angles beginning with the narrowest.

The computed maximum load per unit length of weld is the maximum load divided by the sum of the lengths of all the welds. The computed maximum stress on the throat area is the maximum load divided by the sum of the throat areas of all the welds; that is, the average throat multiplied by the sum of the lengths of all the welds.

For computing the factor of safety, it was assumed that the forces on the shelf angles acted in the faces of the columns. For types A, B, C, D, and E it was assumed that the vertical welds were under shearing stress and the horizontal welds at the heel of the angles under tension and at the toe under compressive stress. Similarly, for type F all the vertical welds were assumed to be under shearing stress and the horizontal welds under tensile stress because the angle deflected.

The stresses recommended by the Code for Fusion Welding were used; that is, shear 11,300, tension 13,000 and compression 15,000 lb./in.[2] on the section through the throat of the weld. Dividing the observed maximum load for each specimen by the safe working load computed in this way, a factor of safety was obtained; these values are given in Table 1. A factor of safety of four is usually considered safe for statically loaded steel structures.

This method of design is admittedly the roughest kind of an approximation. Under V-1, Discussion. Welds, a somewhat closer analysis of some of the types

TABLE 1.—*Tests of shelf-angle connections*

Type and No.	Manner of support	Number of welds on each angle		Dimensions of angles				Total length of weld	Maximum load	Maximum load per unit length	Average throat	Maximum stress on throat area	Factor of safety on throat area [1]	Average width of fracture	Maximum stress on area of fracture
		Horizontal	Vertical	Width—Vertical leg	Width—Horizontal leg	Thickness	Length								
				In.	In.	In.	In.	In.	Lbs.	Lbs./in.	In.	Lbs./in.[2]		In.	Lbs./in.[2]
A-1	Partial	1	0	4	4	5/16	8	16	363,000	22,700	0.31	[2] 73,000	5.6	7/16	51,900
2	do	1	0	4	4	5/16	8	16	412,500	25,800	.29	[2] 89,000	6.8	1 1/32	75,000
3	do	1	0	6	4	1/4	8	16	421,500	26,300	.27	[2] 96,000	7.5	3/8	70,000
4	do	1	0	6	4	1/4	8	16	353,000	22,100	.27	[2] 82,000	6.3	1 1/32	64,300
Average										24,200		[2] 85,500			65,300
B-1	Partial	2	0	4	4	5/16	8	32	556,000	17,400	0.28	67,000	4.8	7/16	39,800
2	do	2	0	6	4	1/4	8	32	473,000	14,800	.22	67,000	4.8	3/8	39,200
3	do	2	0	7	3½	7/16	10	40	612,000	15,300	.28	55,000	3.9	3/8	40,800
4	do	2	0	8	3½	1/4	10	40	535,000	13,400	.31	43,000	3.1	7/16	30,600
Average										15,200		58,000			37,600
C-1	Partial	0	2	4	4	1/4	8	16	173,000	10,800	0.27	40,000	3.5	1 1/32	31,400
2	do	0	2	6	4	5/16	8	24	313,000	13,000	.24	54,000	4.8	1 1/32	38,100
3	do	0	2	7	3½	3/4	10	28	396,000	14,100	.23	61,000	5.4	3/8	37,600
4	do	0	2	8	3½	3/4	10	32	446,000	13,900	.23	61,000	5.4	5/16	44,800
Average										13,000		54,000			38,000
D-1	Partial	1	2	4	4	3/4	6	28	495,000	17,700	0.31	57,000	4.7	3/8	47,100
2	do	1	2	4	4	3/4	6	28	491,000	17,500	.29	61,000	5.0	1 1/32	51,000
3	do	1	2	4	4	3/4	8	32	514,000	16,100	.28	57,000	4.7	3/8	42,900
4	do	1	2	6	4	7/16	8	40	521,000	13,000	.26	50,000	4.2	3/8	34,700
5	do	1	2	7	3½	3/4	10	48	596,000	12,400	.28	44,000	3.7	3/8	33,100
6	do	1	2	8	3½	1	10	52	689,500	13,300	.27	49,000	4.1	1 1/32	32,600
Average										15,000		53,000			40,200
E-1	Partial	2	2	4	4	3/4	8	48	676,000	14,100	0.27	52,000	4.0	3/8	37,600
2	do	2	2	6	4	7/16	8	56	799,000	14,300	.27	53,000	4.1	3/8	38,200
3	do	2	2	8	3½	1	10	72	1,062,000	14,800	.28	57,000	4.4	3/8	39,500
Average										14,400		54,000			38,400
F-1	Full	2	2	4	4	5/16	7¾	27	316,500	11,700	0.24	49,000	4.0	1 1/32	34,100
2	do	2	2	4	4	3/4	7¾	26	359,000	13,800	.24	58,000	4.7	1 1/32	40,200
3	do	2	2	6	4	5/16	7¾	35	504,000	14,400	.27	53,000	4.4	1 1/32	35,400
4	do	2	2	6	4	3/4	8¼	34	488,000	14,300	.34	42,000	3.5	1 1/32	35,300
5	do	2	2	6	4	3/4	8¼	34	480,500	14,100	.32	44,000	3.7	1 1/32	34,800
6	do	2	2	6	4	5/16	9¼	35	447,500	12,800	.25	51,000	4.3	1 1/32	37,300
7	do	2	2	6	4	3/4	9¼	34	433,000	12,700	.24	53,000	4.4	3/8	33,900
8	do	2	2	8	3½	3/4	12¼	40	615,000	15,400	.27	57,000	4.8	5/16	49,300
9	do	2	2	8	3½	3/4	12¼	39	526,000	13,500	.27	50,000	4.2	1 1/32	39,300
Average										13,600		51,000			37,700

[1] Shelf angles designed by the method described in IV, Test Data.
[2] These values for maximum stress are much higher than the value found by the analysis given in V-1, Discussion, Welds, which are, in all probability, more nearly the actual stresses in the welds.

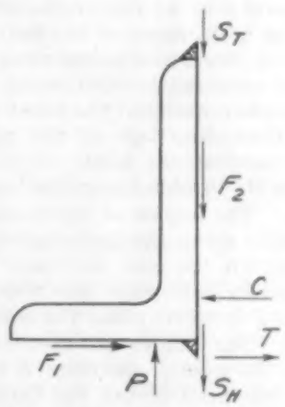


Fig. 4—Free-Body Diagram Showing the Forces Acting on a Shelf Angle and the Welds of a Specimen of Type B Having Welds at the Heel and the toe of the Angle

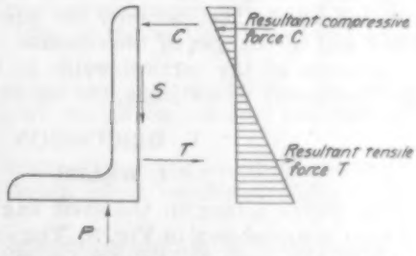


Fig. 5—Free-Body Diagram Showing the Forces Acting on a Shelf Angle and the Welds of a Specimen of Type C Having Welds at the Ends of the Angle

of specimens is attempted. These seem to indicate that the computed values of the maximum stress given in Table 1 are higher than the actual stresses, especially for type A specimens.

As the actual throats were in most cases considerably larger than the throat computed in accordance with the Fusion Welding Code, and some of the welds did not rupture through the throat, the actual width of the fracture was measured. These values are given in Table 1. The maximum stress on fractured area was obtained by dividing the maximum load by the sum of the fractured areas of all the welds; that is, the average width of the fracture multiplied by the sum of the lengths of all the welds.

A detailed account of the behavior of the specimens follows.

Type A.—Horizontal welds along the heels of the angles. The angles of specimens 1 and 3 scaled. The specimens failed suddenly by rupture across the throat of the weld at the maximum load.

Type B.—Horizontal welds along the heels and toes of the angles. The heel welds of specimen 4 scaled and those of specimens 1 and 3 cracked. The maximum loads were only slightly greater than those which caused scaling or cracking. The welds at the heel failed across the throat and those at the toe failed along the leg on the column. The horizontal legs of the angles bent, the thickest angles bending the least. The horizontal legs of the angles of specimen 1 started to shear at the corners of the bearing blocks.

Type C.—Vertical welds along the ends of the angles. Failure occurred by rupture of the weld at the throat, fracture beginning at the lower or heel end of the weld. The outstanding legs of the angles bent, the thickest angles bending the least.

Type D.—Welds along the heels and the ends of the angles. The angles of specimens 2, 3, 5, and 6 scaled. The welds along the heel cracked at the maximum load, after which the load decreased very rapidly. Failure occurred by rupture of the welds at the throat.

Type E.—Welds along the heels, toes, and ends of the angles. The angles of specimens 1 and 2 and the column flanges of specimen 3 scaled. In general, the welds fractured across the throat at the heel and the ends of the angles and along the leg on the column at the toe of the angles. The outstanding legs of the angles of specimens 1 and 2 bent.

Type F.—Both legs of angles welded to the inside faces of the flanges. The welds scaled and the angles bent. The vertical legs of the angles of specimens 4, 6, 8, and 9 also scaled. Failure of the welds began at the toe of the angles. The column flanges of specimens 1, 2, and 7 bulged outward. One angle of specimen 6 sheared at the heel between the edges of the bearing block and the flanges of the columns. Failure occurred by rupture of the vertical welds at the throat and of the horizontal welds along the leg on the column.

V. DISCUSSION

1. WELDS

The forces acting on the shelf angle for a specimen of type A are shown in Fig. 3. The shelf angle on each side of the column is shown to emphasize the fact that the forces are symmetrically arranged with respect to the column. The column and the floor beams are shown by dashed lines. It should be remembered that in this figure the members are shown inverted with respect to the position they would occupy in a structure because the specimens were tested in this position: P is the force applied by the floor beams, S and T are components of the stress acting across the cut section between the weld and the column, C is the resultant compressive force which the column exerts on the vertical leg of the angle, and F_1 and F_2 are frictional forces. The weld will fail when the stress, of which S and T are the components, becomes greater than the strength of the weld. Both F_1 and F_2 reduce the values which S and T would have if no friction were present.

The authors are indebted to O. E. Hovey for the following analysis of the stresses in the specimens of type A:

As under the action of the force P exerted by the bearing block, the outstanding leg of the angle would deflect, the action line of P is probably outside but close to the outer surface of the vertical leg of the angle about in the position shown in Fig. 3.

The pressure of the vertical leg of the angle against the flange of the column would cause bending stresses in this leg of the angle which increase from zero at the toe to a maximum at the fillet. Because of the deflection of the vertical leg, the pressures would be expected to vary approximately inversely as the cube of the distance from the fillet. Opposite the fillet the stress distribution is far from simple and need not be discussed. Below the fillet the pressure distribution would be expected to follow closely the compressive stress in a simple beam taking the centroid of the weld as the neutral axis.

An approximate pressure distribution curve is shown at *o b c d e* (Fig. 3). The action line of the resultant C is probably slightly above the upper surface of the outstanding leg of the angle as shown.

Knowing, approximately, the action lines of the forces P and C and assuming a coefficient of friction (say 0.3), the values of the forces and of the stress on the weld may be computed. The stress computed in this way is about 60,000 lb./in.^{2}

The values of the maximum stress computed on the throat area for specimens of type A given in Table 1 appear to be much higher than the actual stresses and somewhat higher than those computed on the fractured area. A shelf angle designed by the method described in IV, Test Data, would, therefore, be safe. This is indicated also by the high factors of safety given in Table 1.

The forces acting on a specimen of type B are shown in Fig. 4. The forces are similar to those acting on specimens of type A (therefore the notation is the same) with the addition of the shearing force S_T on the toe of the angle. Due to the force S_T, the magnitude of the force S_H is less than in specimens of type A.

The low values of the factor of safety for specimens B-3 and B-4, particularly the latter, raise the question as to the safety of this type of shelf angle when designed in this way. It should be pointed out that if specimen B-4 had been the only one tested, it would have been concluded that the factor of safety of this type of shelf angle was only 3.08.

A discussion of the forces acting on specimens of type C is given later under V-2 (*a*), Angles, Width. For these specimens the stress in the welds is, for the most part, shear. Shelf angles of this type designed as described in IV, Test Data, may be satisfactory, although specimen C-1 showed a low factor of safety.

For types D, E, and F the variation in the number and position of the welds and in the width and length of the angles is too complex to warrant an analysis based on the limited number of tests.

Shelf angles of these types designed as described in IV, Test Data, might be safe, although specimens D-5, E-1, and F-1, 4, and 5 showed factors of safety less than four.

The bending of the shelf angles of type F probably caused high local stresses in the welds resulting in the low factors of safety.

2. ANGLES

(a) WIDTH

There are no definite indications that the width of the vertical leg of the angles affected the strength of the specimens of types A, D, E, and F. For type B there is a decrease and for type C an increase in the maximum stress with an increase in the width of the angle.

For specimens of type B the distribution of the load between the heel and toe welds depends on the stiffness of the vertical leg of the angles. The greater the width of the vertical leg, the larger will be the deformation. As a result the heel weld carries a larger proportion of the load for the lower loads. At and near the maximum load, however, the load must be distributed approximately equally because the welds in all probability have sufficient ductility to detrude at the maximum load, enough to equalize the loads. Tests upon longitudinal fillet welds, similar to these, showed that the detrusion was about 0.1 in. before the load decreased appreciably from the maximum. For the angles having an 8-in. vertical leg a detrusion in the heel weld of only 0.01 in. more than the toe weld would appear to be all that is necessary to equalize the loads. This detrusion must occur in a direction perpendicular to the direction of the weld, and might not reach the value found for the detrusion in the direction of the weld.

The forces acting on a shelf angle of specimens of type *C* are shown in Fig. 5. *P* is the external force applied to the angle, *S* is the sum of the friction and the shearing force on the welds, *C* is the resultant compressive force between the column and the toe of the angle and upper portion of the welds, *T* is the resultant tensile force on the lower portion of the welds. The angle is in equilibrium under the action of these forces which form two opposing couples. If the width of the vertical leg of the angle is, for example, doubled and the load *P* is also doubled (the average shearing stress in the weld remaining the same), the magnitude of the forces *T* and *C* will not change since their moment arm is doubled. As a result the tensile stress in the lower portion of the weld will be reduced to one-half its former value, while the shearing stress will remain unchanged. The resultant stress in the lower portion of the weld will, therefore, be decreased as the width of the vertical leg of the angle increases, and a greater maximum load per unit length will be required to cause failure. This is approximately confirmed by the increase in the value of the maximum stress (type C, Table 1) with an increase in the width of the vertical leg of the angle.

(b) THICKNESS

No definite conclusions can be drawn regarding the effect of the thickness of the angles on the strength of the connection. In type C there is an increase in strength with increase in width. The higher loads carried by the wider angles may be due, in part, to their greater thickness.

If we exclude the specimens of type A for which the thickness of the angles, obviously, had little effect upon the maximum stress, we find the following average maximum stresses on the throat area: Angles ½ in. thick 40,000 lb./in.^{2}; ⅝ in. thick, 54,800; ¾ in. thick, 55,000; ⅞ in. thick, 50,200; and 1 in. thick, 53,000. It is evident that the thickness of the angles has practically no effect upon the maximum stress, at least for angles thicker than ½ in.

(c) LENGTH

Since the length of the angles ranged from 6 to 12 in. and the load was applied only over the middle 6 in., there were bending stresses in the direction of the length of the angle. These bending stresses might be expected to lower the values of the maximum stresses given in Table 1 for the longer angles.

The angles for specimens of type A were all 8 in. long so no conclusions can be drawn from the results on these specimens. Considering only specimens of types B, C, D, and E, the average maximum stress on the throat area for the angles 6 in. long is 59,000 lb./in.^{2}; for the angles 8 in. long, 55,000; and for the angles 10 in. long, 52,900. These values tend to confirm the assumed effect of bending stresses, but the differences are small and may have been caused by other variables.

For specimens of type F, the average maximum stress on the throat area for the 7¾-in. angles is 53,300; for the 8¼-in. angles, 43,000; for the 9¼-in. angles, 52,500; and for the 12¼-in. angles, 53,500 lb./in.^{2} It is evident that for these specimens the length of the angles has very little effect upon the stress. As they were supported only at the ends, the bending stresses were probably higher than in the specimens of the other types. The conclusion seems justified that the maximum stress is practically independent of the length of the angle for all of these specimens.

VI. CONCLUSIONS

Shelf angles for transferring loads from floor beams to columns in steel-frame buildings were arc-welded to H-section columns. The types of weld connections used were: Single weld at heel of shelf angle; welds at heel and toe of angle; welds at ends of angle; welds at heel and ends of angle; welds at heel, toe, and ends of angles; and welds at ends of angles fitted between the flanges of the H-section. The specimens were tested to destruction with the following results:

1. Each specimen failed through the weld. Therefore, the properties of the material in the column and in the angles had little or no effect upon the values of the maximum load.

2. For the specimens having welds only at the ends of the angles the average maximum stress in the welds increased as the width of the vertical leg of the angle was increased.

3. There were no definite indications that the width of the vertical leg of the angles affected the strength of the specimens.

4. Neither the thickness nor the length of the angles appeared to have much effect on the strength of the specimens.

5. Shelf-angle connections similar to those tested in this investigation, with reinforced fillet welds, will have a factor of safety of about 4 if they are designed with the following assumptions: (*a*) The forces act in the face of the column; (*b*) vertical fillet welds are stressed in shear; (*c*) horizontal fillet welds at the heel of the angle are stressed in tension; (*d*) horizon-

tal fillet welds at the toe of the angle are stressed in compression, and (*e*) the allowable stresses are those given in the Code for Fusion Welding and Gas Cutting in Building Construction prepared by the American Welding Society.

Resistance Welding of Motor Frames

By MALCOLM THOMSON

✦ This paper was prepared by Mr. Thomson, Engr., Fabrication Dept., General Electric Co., Lynn, Mass., and presented at the Winter Convention, A. I. E. E., N. Y., Jan. 26-30, 1931.

THE continual demands of modern industry have caused and are causing a continual revision of methods employed. Perhaps no more interesting application of electricity to shop manufacture occurs than in its use in various forms of electric welding. The methods in most common use are the arc methods, the carbon arc and the metallic arc, and the resistance method. The carbon arc process was invented by DeMeritens in France in 1881 and the metallic arc

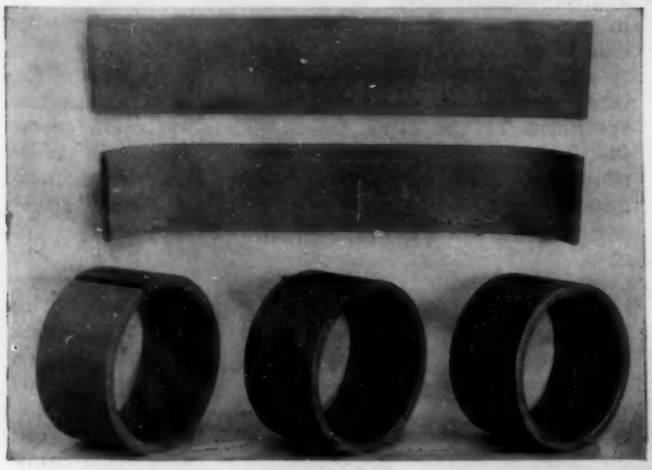


Fig. 1—Rolled-Plate Automotive-Motor Frame. Views Showing Successive Stages in Forming

process by Slavianoff in Russia in 1890. The resistance welding process was invented by Dr. Elihu Thomson in 1886. It is this latter process which is particularly adapted for use where there is mass production.

In the manufacture of motor frames, competition brings in the question of reduced costs. It was, therefore, natural that the General Electric Company took steps in 1928 to equip a modern shop for fabrication of motor frames, as well as other products which could be fabricated from structural steel. A section of a building formerly used as a steel foundry was set aside for this purpose. The manufacture of rings for frames of d-c. motors is briefly outlined as follows:

The steel for the rings is ordered from the mills in carload lots of the proper width and length, the length being figured so as to include the necessary amount for welding and sizing operations. The steel which has been found most suitable for magnet frames is a basic open hearth process manufacture of low carbon content. The slabs of steel are unloaded at one end of the department, and are of various sizes in accordance with different sizes of magnet frames. The slabs are passed to a 1200-ton hydraulic press which crimps or curls the ends to avoid flats and waste of stock at portions which cannot be rolled.

A view showing the steel as purchased and crimped, and also rings, as rolled, welded, and sized is given in Fig. 1.

Fig. 2 shows a typical ring in bending rolls. Attention is called to the vertical plate which insures accurate

Fig. 2—Rolling Machine for Fabricating Automotive Motor Magnet Frames

alignment of the ends of the ring during rolling process. The rolls have electric motor drive for raising and lowering rolls, as well as motor drive for rolls. The end section is pivoted and controlled by an air cylinder which is shown in the figure. This feature is for quick removal of rings.

From the rolls the rings pass by a conveyor which has considerable storage capacity to a specially designed resistance flash welder.

Fig. 3 shows this welder in action. The rings are

Fig. 3—Specially Designed Resistance Flash Welder in Operation

held with powerful clamps actuated by hydraulic cylinders against special aluminum bronze die blocks. The operator separates the ends of the rings slightly, then starts slowly feeding the jaws of the machine together with a hand valve control of a hydraulic push up

cylinder. The current is turned on by a push button working a small contactor which in turn controls a large contactor, the latter closing the connection of the primary of the transformer to the power lines. As the ends of the ring meet, at first feeble then violent flashing occurs. A predetermined amount is flashed off, averaging slightly less than an inch total. The flashing heats the abutting faces to the melting point of steel and the area immediately behind to a welding heat mainly by conduction, but partly by resistance. At the end of the flashing period, the full pressure of the hydraulic ram or about 100,000 lb. is applied, suddenly forcing the molten faces together. The result is a perfect and homogeneous weld, all burnt or oxidized metal being forced out. This welder while rated at 12 sq. in. maximum, cross section is used on sections up to 18 sq. in. The welder has a 750-kv-a. water-cooled transformer. The open circuit voltage at welding jaws is 12 volts.

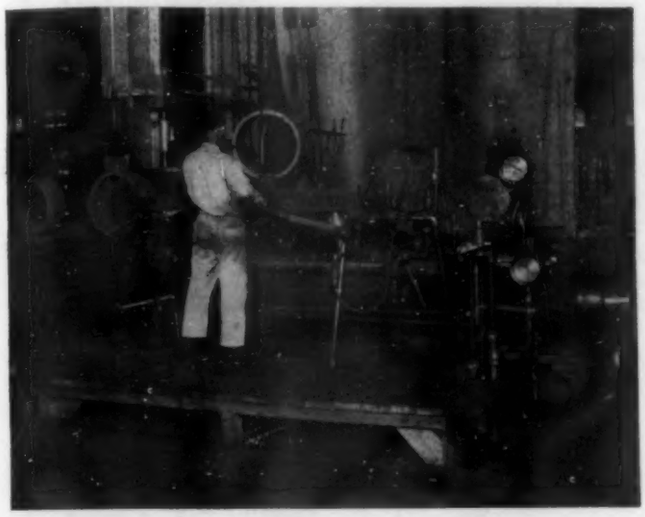


Fig. 4—Electric Hoist Removing Ring from Welder

Fig. 5—Arc Welding, Building 30, River Works

The demands on welding transformers call for different features of design other than those used with the usual types. The service is intermittent but large amounts of current are necessary, particularly at the final or upset period of the welding cycle. Due to the severe nature of the service, accessibility is an important feature, hence the coils are usually assembled on a straight core section, then a "U" shaped section is placed in position and fastened to the straight section with bolts and straps. This allows for more easy repair in case of trouble. On 60-cycle supply, the core is worked at a flux density of 60,000 to 80,000 lines per sq. in.

The secondary is usually of cast copper with cooling tubes for water cast in and of single turn type. In larger transformers usually several cast copper sections are connected in parallel. The ends of the copper secondary are machined, one end being fastened solidly to the fixed platen. The other end is bolted to a flexible lead made up of many thin sections of copper strip, this lead being connected to movable platen. The welding dies are located on top of the platens and are of hard rolled copper or special wear resisting material, depending on nature of service. The work is very solidly clamped to the die blocks because of the push up pressure required. The cast copper is worked at a current density of 1800 to 2200 amperes per sq. in., the flexible leads at 2000 to 2400 amperes and the joints at 400 to 600 amperes per sq. in. The dies are worked at about 3000 amperes per sq. in. current density. Dies and platen are wherever possible, water cooled internally. The two sides of the secondary are kept as close together as possible and the length of this circuit kept at a minimum to avoid any unnecessary secondary voltage drop.

Primary coils of the larger type transformers are usually built up of copper strip insulated between layers by a sleeve of cloth or layer of asbestos paper. The coils are impregnated and baked, then wound with tape and finally painted.

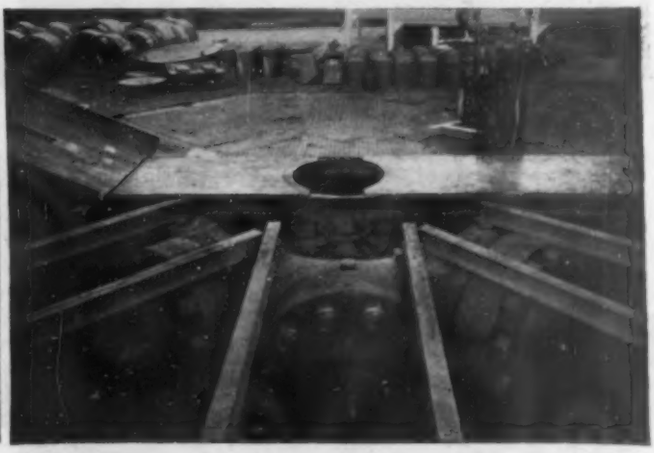


Fig. 6—Hydraulic Press for Fabricated Automotive-Motor Magnet Frames

Voltage regulation on the primary is obtained either by use of a separate auto transformer or by bringing out taps, a regulating switch being employed. Usually there are from five to ten points of voltage regulation, the lowest being about 50 per cent of the highest.

Contactors used to switch on the power supply must

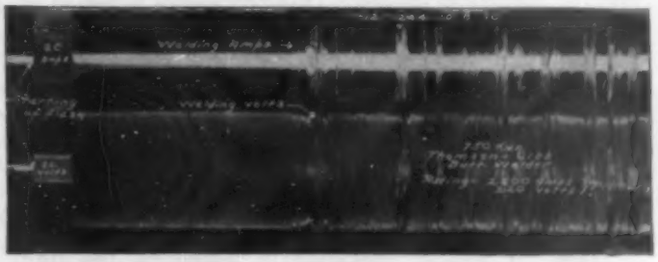


Fig. 7

be able to break full load of welder without undue arcing. On production work the breaking of the current may occur several times a minute.

The transformers are usually designed for one particular job; that is, a transformer designed for flash welding of steel would not be suitable for fast upsetting, and one designed for steel not suitable for welding copper or aluminum.

The transformer in the particular machine described was designed especially for welding of rings up to 12 sq. in. cross section, but as previously stated, is used on somewhat heavier sections also.

Readings taken while welding section of 18 sq. in. show that there is a primary current of about 900 amperes taken during the flashing period with a peak load of 2250 amperes at the final or completion period of weld when the ring is forced together. The primary voltage is 236. Current is at 60 cycle frequency. At high point of weld, readings taken show 461,250 volt-

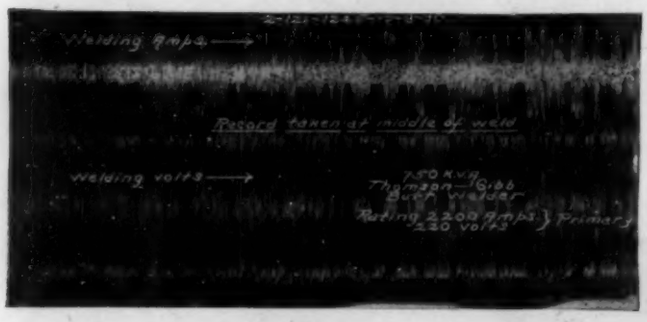


Fig. 8

amperes and 252,000 watts which gives a power factor of about 55 per cent. The average watts during flashing is 126,000; 1400 watts are taken with secondary open.

Oscillograph records have been made on this welder which are reproduced in Figs. 7 to 11 inclusive. Fig. 7

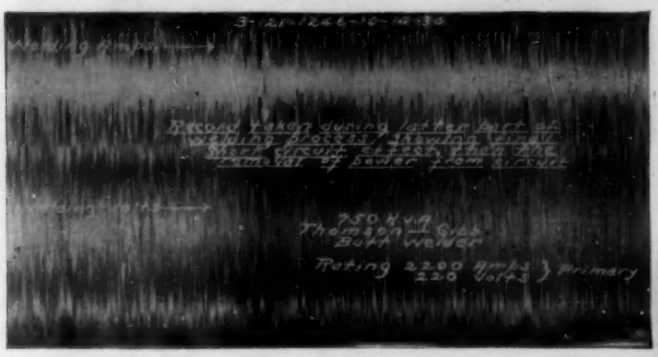


Fig. 9

shows conditions at start of flash, first a brief interval of short circuit, then open circuit followed by beginning of contact of pieces. This represents a period of feeble flashing. As the flashing becomes more violent, conditions are as in Fig. 8. Toward the end of the flashing period, as shown in Fig. 9, when flashing appears continuous, the wave form still shows no continuous flow of current, but rather closely compact intervals of shirt circuit and open circuit. This picture also shows the upset or final push up section of the weld. Figs. 10 and 11 show views of wave analysis at early stages and near final stage of flashing period.

After the welding operation is completed, the ring is removed by an electric hoist shown in Fig. 4. The upset and flash resulting from the welding operation show clearly in this view. This is removed, the operation being done in a vertical motor-driven broach which trims outside and inside while the metal is still red hot. The rings then pass by a conveyor similar to that pre-

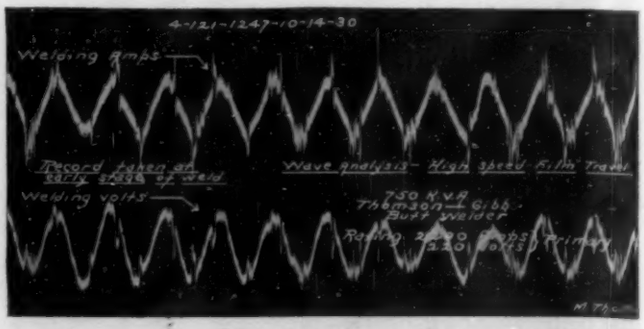


Fig. 10

viously shown, to an electric furnace. The electric furnace, while primarily used for heating rings for sizing, also is advantageous in that it gives a strain anneal. The furnace is shown in Fig. 5. The rings on the floor are complete rings ready for shipment. Those in the front rows have feet welded on.

The rings are heated to about 1400 deg. F., in the furnace and then pass down a slide to an eight-cylinder hydraulic press located in the floor as shown in Fig. 6. Part of the flooring has been removed to show construction of the press. The press is so constructed that each cylinder has a removable head portion so that various sizes of rings may be accommodated. The rings are lowered horizontally into the press by means of an air-operated table and then squeezed to vary within 1/16 in. to 3/32 in. of correct size, depending on size of ring.

The ring is now complete with the exception of feet. The feet are made from steel bent into a U form in the hydraulic press, then gas cut apart. Each U makes one pair of feet and by inverting the U's, the right and left are made. It is the practise to cut all four feet at once using a double torch machine for this purpose.

The sized rings pass by conveyor to arc welding stations where the feet are tack welded, then finished welded into place. The completed frames are then sand-blasted, after which they are shipped to the motor building for machining and assembly.

Some of the rings are for automotive equipment and

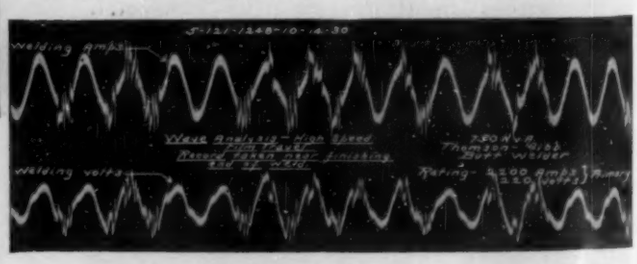


Fig. 11

do not have feet. These latter rings have dropped forged arms and bearing retainers welded in place by metallic arc process.

By the use of electric welding of two kinds, it has been possible to produce frames 25 to 50 per cent cheaper than corresponding steel castings with added advantage of much greater uniformity in dimensions and structure. This, in turn, reflects in lowering machining costs and better motors.

Arc Spark Test for Metals

By C. J. HOLSLAG

✦ This paper was prepared by Mr. C. J. Holslag, president of the Electric Arc Cutting & Welding Co.

WE have discovered a phenomenon that I think will be of very much interest to your readers and would like their comments.

We are sure we can identify every kind of welding rod by the spark it gives off in the arc or by scratching it along a metal surface with current through it so that sparks are given off. We have tried a great many kinds of metals and alloys, and they all seem to have a characteristic appearance or action which would allow anyone who has seen them once to identify them again.

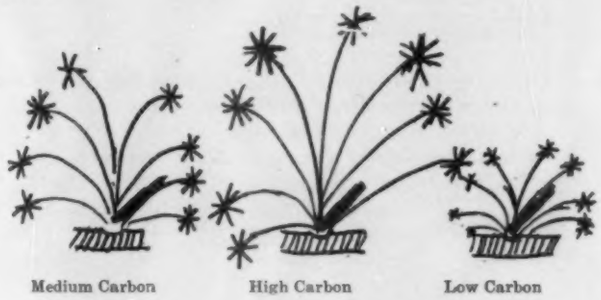


Fig. 1

Carbon in a plain steel rod shows itself up unmistakably by a little explosion like that at the end of Italian fireworks. The explosion being a star (Fig. 1) at the very end of the spark, that is, where the spark disappears. Not only does carbon show itself up, but the amount of carbon is indicated by the size of this explosion and the distance from the arc puddle. 0.9 carbon the star or explosion is the size of a penny, .65 a dime, .8 a nickel, while .15 is small like a thumb-tack head. That is, the higher the arc, the bigger the explosion, and I dare say if a person has seen this once he can spot ten points of carbon by the size of the star and guess to with 5/100 of 1 per cent and that if a test rod of known carbon is used alongside as a reference guide, he can tell within 2/100 of 1 per cent. This is as good as is done by an analysis, and this test makes itself known wherever a welding rod is used. All you have to do is to walk up behind an operator and look alongside, not through his shield, and see the sparks. The reason we are giving a characteristic appearance of carbon first is because it appears in nearly every other alloy and you first have to learn the carbon explosion so as not to be fooled when looking for other alloys such as manganese, vanadium, molybdenum, tungsten, etc. This appearance of carbon is only in steel alloys, where it is present in chemical combination with the steel. Where it is a mixture like in cast iron, the spark is not very bright—a dull red and no explosion at the end of it. However, there are so many other ways of telling a cast iron rod, we just mention this to show that, perhaps, at about 1½ per cent of carbon the characteristic appearance undergoes a distinct change. If there is no spark present, with or without explosion, the iron is less than five hundredths carbon, that is, so-called pure iron or low carbon Swedish iron or commercially pure iron.

Manganese has its own appearance as indicated by Fig. 2:

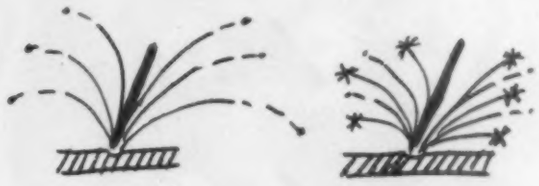


Fig. 2

With a bare wire or wire cleaned of its covering, carbon also shows itself by the presence of floating particles in the air similar to lazy mosquito larvae in water, the size of the floating particles indicating the amount of carbon. Manganese alloy with various amounts of carbon will have the manganese appearance, coupled with the carbon explosions. If it's a lot of manganese, such as .11-.13% mn., the carbon explosions will be overshadowed by the manganese dots, but if it's the ordinary manganese in the welding rods, such as .04 to .06% mn., the manganese will have to be looked for carefully in order that the carbon explosions may not overshadow them.

Of course, in the arc test you must take in consideration the characteristics of the parent metal and for careful work use only pure iron; but for a rough test, the parent metal sparks come from the puddle failing after the arc is over; hence, judicious guessing will tell contents of both metals.

Molybdenum alloys have a beautiful characteristic spark as shown in Fig. 3:

Fig. 3

Molybdenum does not interfere with any other determination, as its characteristics are so marked like spears or darts.

Tungsten, another tool steel alloy, is clearly indicated by the intense white balls of fire given off, as per Fig. 4:

Vanadium acts similarly, but the balls exploding into stars, but different from carbon (Fig. 5):

Nickel is evidenced by its absence of whiteness and its red balls of fire sort of rolling along (Fig. 6):

Chromium, in addition to the characteristics shown in Fig. 7, has a characteristic green-white color, and copper and brass a greenish colored spark. The presence and amount of zinc in brass or bronze can be judged by the white fluff given off, which is zinc oxide.

Cobalt has a bluish colored fountain (Fig. 8):

Copper has a greenish color, so that once seen will not be confused with chromium (Fig. 9):

Aluminum, duralumin and similar metals give a rolling ball spark much whiter than nickel, but we have discerned no way to definitely tell the difference between these light metals.

Nickel and chromium are a pair found together in

these new stainless steels, and whether there is more chromium than the nickel or vice versa can be judged by the volume of the two characteristics.

From what we have tried and seen, I think every alloy has its own characteristic appearance. The running through the arc or scratching with current on of every rod writes its name and own instantaneous picture of the analysis.

Fig. 4
Tungsten

Fig. 5
Vanadium

Fig. 6
Nickel

The coating content on a rod can be told also by the arc. For instance, silicates quiet the arc; calcium and its brothers and sisters, barium, strontium, etc., lower the temperature at which an arc will hold, and carbon or any metal in the coating will show its signature as described, so that by trying the rod with and without coating both contents can be determined.

Try the ones I have outlined and try some new ones and write me about them. I would like to know if you can check my observation and whether you can add the characteristics of any other rods.

This is admittedly a preparatory article to start thought along these lines and would make a fine thesis for several students or metal research workers.

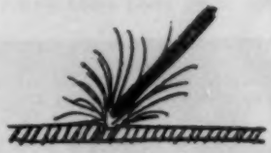


Fig. 7
Chromium—Color, White

Fig. 8
Cobalt—Color, Blue

Fig. 9
Copper—Color, Green

Welded Truck

By W. E. FARRELL,
President Easton Car & Construction Company

THERE are shown two photographs of an arc welded platform car for shipment to South America. This truck is designed to carry a pay load of 16 tons with provision to withstand a 25 per cent additional impact load.

The body of the truck was originally designed as a steel casting. The car was redesigned so that the platform was made of plates arc welded together. This redesign resulted in a considerable reduction in the weight of the car and a material saving in cost.

Fig. 1—Top View of Car

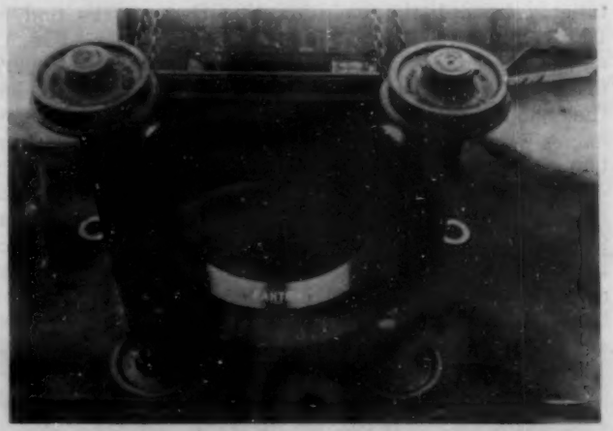


Fig. 2—Bottom View of Car

An interesting feature in connection with the car is the location of four holes in the top of the car to meet the customer's requirements of a tolerance of plus or minus one-hundredth of an inch from center to center. As is quite apparent, considerable amount of machine work was saved as compared with that which would have been required for a steel casting for the top.

The plates having these holes were properly located, tacked and after being checked by the inspector the welding was completed. Although this was the first job and some extra expense involved in checking the design, the total cost was less than the design which involved a steel casting.

Arc Welding Used on the Steel Work of the New Wilson Factory

By J. A. QUARMBY

✦ Mr. Quarmby is connected with the Wilson Welder & Metals Co.

WHEN the need of larger facilities made it necessary for the Wilson Welder & Metals Co., Inc., to build a new plant, they not only took the opportunity of building a scientifically laid-out factory, from the standpoint of production, but they also took the opportunity of erecting, for themselves, a structural steel job in which arc welding was used exclusively.

The factory building is of steel and brick con-

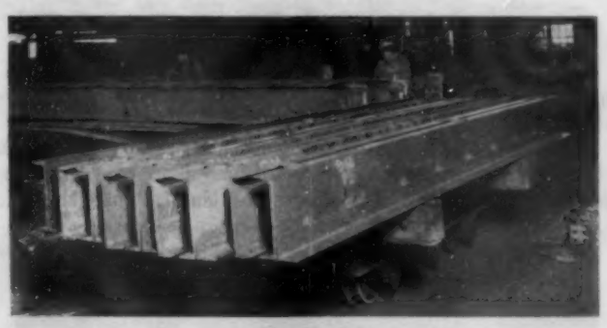


Fig. 1—Beams in Process of Fabrication

struction. All welding was done in accordance with American Welding Society specifications.

The columns and beams were fabricated by arc-

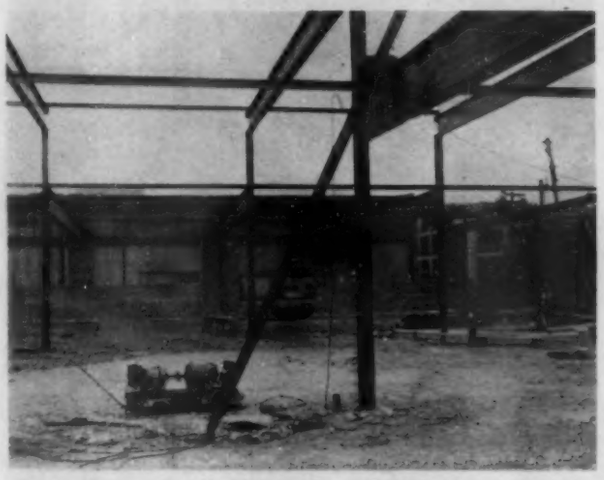


Fig. 2—Erection of Frame Work

welding in the structural steel shop and transported to the factory site, where the cross-beams were arc welded to the uprights. The picture, Fig. 1, taken in the structural steel shop, shows some of the beams being fabricated. In the foreground is a load of lintels for the door openings.

A view of the steel work in process of erection is shown in Fig. 2. The operator can be seen welding the I beam to the upright just back of the ladder.

Arc welding effected a considerable saving in the tonnage of structural steel used and in the cost of both fabricating and erecting, and resulted in much stronger and neater joints. The following data is of interest:

Tons of structural steel	74
Inches of ⅜-in. fillet shop welding	4,180
Inches of ⅜-in. fillet field welding	1,030
Total pounds welding wire	165
Pounds welding wire per ton steel	2.23
Feet of fillet welds per ton steel	5.86
Per cent steel saved by welding	10

In addition to the structural work, the boiler, tanks, tracks and supporting hangers for the portable crane monorails were arc-welded. This saved considerable in the weight of steel used and the cost of installation. All work benches, bins and racks were also arc-welded.

Oxy-Acetylene Welding Aids in Motorcycle Production

By V. H. VAN DIVER

✦ Mr. V. H. Van Diver is connected with the Linde Air Products Co.

THE weight-saving resulting from the use of welding is an important factor in the use of this production tool by motorcycle manufacturers. The object of production here is to make a powerful and sturdy machine as light as possible, and this object is attained by welding which eliminates the bulky and heavy fittings and joints of other methods.

In one department of a modern motorcycle plant the welding blowpipe is used to fabricate steel handle-bars. In motorcycle work these are highly important parts since the handle-bar is not only the steering gear but in addition carries several controls. Because the handle-bars contain the throttle and spark controls, they must be not alone sturdily but precisely built as well. Handle-bars are formed from rolled sheet steel, oxy-acetylene welded as a unit, and finished.

Fig. 1—Finished Side Cars

Another plant uses both the welding and cutting blowpipes in the production of steel motorcycle side car bodies. These are cut from heavy gage sheet steel and then welded. In Fig. 1 is shown a group of finished cars. Because they are welded they are stronger and of better appearance.

Structural Arc Welding a Review of What Has Been Accomplished and Its Future

By A. F. DAVIS

✦ This paper was prepared by A. F. Davis, vice-president of the Lincoln Electric Company and was presented at the Western Metal Congress, Feb. 16-20, 1931, San Francisco, Calif.

A YEAR or so ago the Board of Directors of the Irving Trust Company of New York sent out engraved notes of apology to some five hundred of their neighbors, asking their indulgence "during the unavoidably noisy weeks that lie just ahead" while the steel frame of their new building was being erected. Some time after this, the Union Trust Company of Cleveland added part of another floor to their twenty odd story building, but they sent no apologies for noise—they welded.

Fig. 1—Arc Welding an Addition to the Twentieth Floor of The Union Trust Company Building

When Structural Arc Welding is mentioned one automatically thinks of buildings which are erected in the field, either wholly or in part, by arc welding. However, it seems to the writer that there are two distinct phases of the subject, namely:

1. Field erection or construction.
2. Shop welding of structural members and details such as trusses, details, etc., which may be used in buildings erected or constructed in other ways than by welding.

Each has its distinct problems and it is our intention to more or less treat the subject in this way.

In order to get a picture of the present status of structural arc welding it seems desirable to give a brief history of what has transpired in its application to the erection of buildings, then to point out a few of the questions and what is being and has been done to solve them.

Fig. 2—Arc Welded Bridge in Toronto, Ontario, Canada

The steel frame work carries the entire load, the concrete being used largely for protection. This picture taken during construction and shows the false work

So far as the writer knows, the first structure in this country in which arc welding was used in an important part was the old plant of the Lincoln Electric Company in 1916.

A four-story concrete block building had its floors seriously overloaded and the blocks began to crumble. A complete welded steel structure was built into the existing structure without disturbance to the factory operations.

Fig. 3—Peoples Outfitting Building, Detroit, Mich.

In an addition to this building (new part on right side) there were 105 new girders welded to the existing structure without disturbing the usual routine of the Department Store housed in the building. Albert Kahn, Inc., Architect

In the Province of Ontario, a highway bridge of three spans, 672 ft. over-all, carrying the heavy traffic

into the city of Toronto, was constructed in 1923 of arc welded steel and concrete. The design of the bridge was unique. All of the steel work was made up of round bars. The steel carried the entire load, the concrete serving solely as a protection for the steel. Before this bridge was built the design was severely criticized by engineers not familiar with the possibilities of arc welding. However, the designer knew what

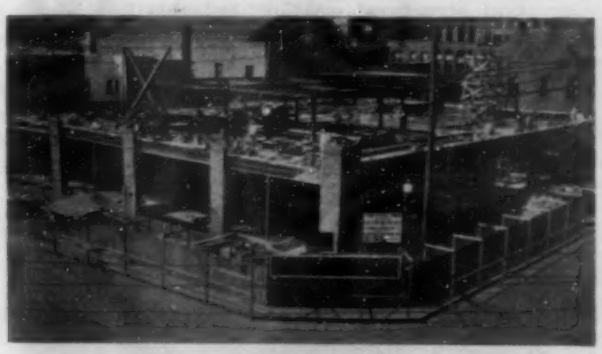


Fig. 4—Peerless Auto Sales Company Building of Canton, Ohio, Erected in 1925 by The Morgan Engineering Company, Alliance, Ohio. Fabricated and Erected by Arc Welding

could be accomplished. The bridge was built and it met all required tests, and it was built at a cost far below that of riveted construction.

About this same time there was constructed by the Graver Corporation an arc welded swimming pool in the Standards Club of Chicago and also a pool in the Union League Club of Chicago.

It was only shortly after this that in Detroit the steel framework of a 12-story addition to the Peoples Outfitting Company building was arc welded, where the floor girders were framed into the columns, at a considerable saving of both money and inconvenience.

In the early part of 1925 the writer was approached by the late Mr. Richard Storm of the Morgan Engineering Company of Alliance, Ohio, as to the advisability of completely welding the Peerless Auto Sales Company Building of Canton, Ohio.

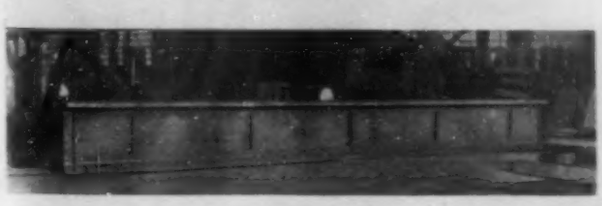


Fig. 5—Arc Welded Main Girder of Runway for 100 Foot Span Overhead Traveling Crane

This girder consists of a web plate, two angles on the bottom flange and two angles and a cover plate on the top flange and the necessary stiffners. Girder was approximately 40 feet long and 3 feet in height

Although originally designed as a riveted job, the contract awarded on a competitive basis and the shop details made for riveted construction, it was decided to weld the job throughout.

In changing from riveted to welded connections on this job, it was not with the expectation of cutting costs, but with the belief that a more satisfactory structure would result. The change resulted in a clean-cut job, completed on schedule time, at a saving in both time and money.

This building was 100 ft. by 150 ft., and consists of two stories and basement with an auto ramp, and was —so far as known—the first commercially all-welded building.

At approximately the same time the same company constructed a large crane runway in which were used 16 A frames and 14 large built-up girders, all fabricated by welding. A great deal of credit is due Mr. Storm for his foresight and ability in pioneering welding.

In November of 1926 there was erected by the Westinghouse Electric & Manufacturing Company at Sharon, Pa., the then largest all-welded steel frame

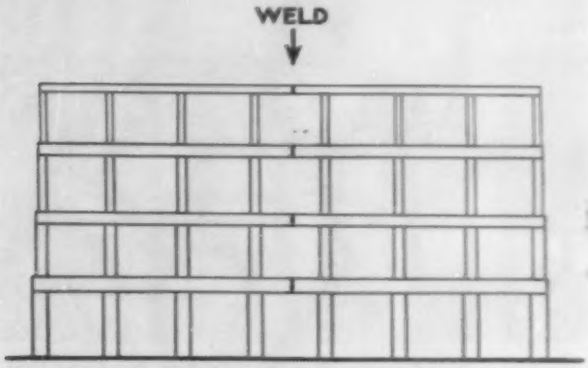


Fig. 6—Method of Stepping Columns Used in Design of Upper Carnegie Building, Cleveland, Ohio

Note that the size of the columns is decreased at each floor resulting in saving material. Note also girders are continuous the entire length of building and welded in the middle. This also resulted in a considerable saving in material

Fig. 7—Upper Carnegie Building Under Construction. This Also Shows the Through Girders and Stepped Columns

building. This was a five-story warehouse which utilized 790 tons of steel.

Shortly after this a number of buildings were erected by this process, one of the most interesting of which was the Upper Carnegie Building, erected by the Austin Company in Cleveland. This was a four-story building, 60 ft. by 119 ft., which, while not large, embodied several unique features, among which was the use of continuous beams which were welded in the middle of the building and the use of columns broken at each floor.

Since this time there have in all been a considerable

number of buildings fabricated by welding. Among them are:

The Factory Building at West Philadelphia. Works of the General Electric Company, consisting of approximately 1000 tons of steel.

The Homestead Hotel Building at Hot Springs, Va.,

Fig. 8—The Welded Connection of the 36 In. Bethlehem Girder Used in the Front of the Upper Carnegie Building Supporting the Upper Part of the Building Above the Store Front

This joint was welded in the middle of the bay by scarfing and welding the two ends of the girder and by placing a topping plate on top of the girder, which was welded entirely around the plate onto the top of the girder and also by placing a strap on the inside of the bottom flange on each side of the girder

fabricated and erected by the American Bridge Company.

The power plant adjoining the Chalfont and Hadden hotels at Atlantic City, N. J., fabricated and erected by the Bethlehem Steel Company.

The 14-story, 1400-ton office building of the Edison Electric Illuminating Company of Boston, Mass.

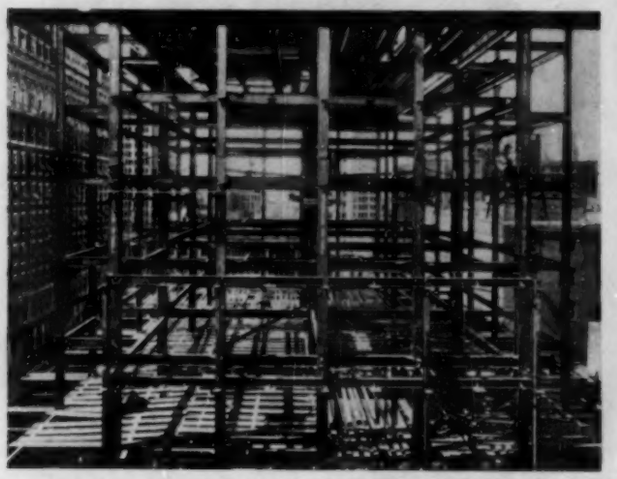


Fig. 9—Ninteen Story Building of Dallas Light and Power Company, Dallas, Tex., During Erection of Steel Work by Mosher Steel Company

The 3000-ton shop, riveted, field welded building of the Southern California Edison Company at Los Angeles, Cal.

The 19-story building of the Dallas Light and Power Company at Dallas, Tex., erected by the Mosher Steel Company.

The Dallas Gas building, Dallas, Tex., designed for 22 stories, of which 14 stories are being erected at present.

Recent statistics collected by the American Welding Society show that welding has taken a prominent part in over one hundred buildings or structures, with an estimated tonnage of over 100,000. Doubtless there are many more, and now almost daily we hear of new welded projects. Municipal Building Codes have been one of the factors that has retarded the more rapid progress of structural welding, but this bar is being gradually removed. More and more cities are adopting, either wholly or in part, the welding code suggested by the American Welding Society. Today the known number of cities that have changed their code is probably at least one hundred, and it should be gratifying to Californians to know the large percentage

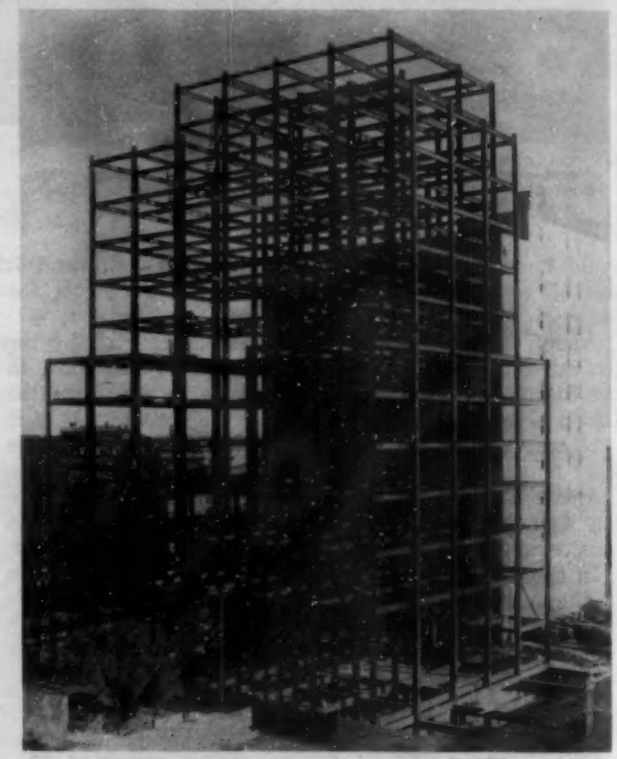


Fig. 10—Arc Welded Frame Work of Dallas Gas Building, Designed for 22 Stories of Which 14 Stories Have Been Constructed. Austin Brothers, Fabricators and Erectors

of those cities located in California. Copies of the recommended code can be secured from the American Welding Society.

The reliability of welding is often questioned, particularly by those who are not familiar with the process. However, it is interesting to note that out of the large number of welded buildings, so far as it is known, there has not been a single failure, and this in spite of some very severe tests. As an example we would like to cite several cases which have come to the writer's attention. There have been in recent years quite a number of packing houses erected in Florida of steel arch construction by the Arch Construction Company of Orlando, Fla., the arches being constructed entirely by arc welding. The framework of one of these buildings was almost entirely finished and a good share of the masonry when a hurricane came along and approached the building from the rear, blowing in the rear wall—going through the entire length of the structure and blowing out the front wall. The bar

joists had been welded in place on the supporting beams by short fillet welds along the edges of bearing plates at the ends of the joist, and even though the entire wall fell on these bar joists, causing them to bend almost to the floor slab, the welds held the joists to the beams, causing even the beams and the supporting columns to become badly distorted. In order to clear the wreckage it was necessary to cut the bar joist from the beams by gas, the welds still being in practically perfect condition.

Recently a cyclone struck the Houston (Tex.) airport, causing a damage of approximately $50,000 to planes and a masonry hangar, but passing over three arc welded steel hangars alongside, without even causing a dollar's damage.

Fig. 11—Steel Arch Type of Arc Welded Building Destroyed by Hurricane With Not a Weld Parting

This view shows the distortion of the beams and joist after some of the joist had been cut from the beams by gas

There are numerous other examples which show that welded structures which, when done with proper procedure and inspection, are perfectly reliable.

Another question frequently heard is as to the uniformity of welds. We think it safe to say that with proper procedure and inspection a uniformity equal to that of any other mechanical type of joint will be secured. A year or so ago the American Welding Society started a program of testing a large number of welded specimens in order to

1. Confirm or qualify previous results by the use of a larger number of specimens and a more uniform system of testing.
2. Supplement the scope of previous data by tests on additional forms of joint.
3. Determine what degree of uniformity in commercial welding may be expected.

The program covered 57 forms of joint in 191 sizes welded by the gas or the arc process. The specimens were of elemental type and embraced fillet welds of lap and tee form, end and edge butt welds, and special joints. Single and double lines of weld, normal, parallel and diagonal to direction of stress, continuous and intermittent, were specified.

Specimens were to be subjected to static tests for ultimate strength, yield point and ductility. These might be supplemented by dynamic and other special tests. The general aim was to proportion specimens so that they would fail in the joint and thus indicate unit weld strength, but for check purposes a few types were included that would probably fail in the base metal.

In order to determine what degree of uniformity might be expected in commercial practice, multiple specimens of each type and size were scheduled, whose preparation was distributed among about thirty-six representative fabricating shops throughout the United States and Canada. Operations were governed by uniform procedure and inspection regulations.

Quite a number of tests have been completed and

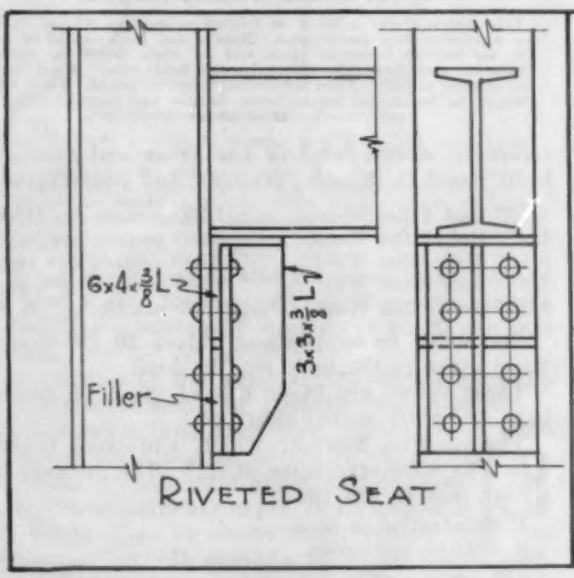


Fig. 12—Riveted Beam Seat for Load of 45,000 Pounds

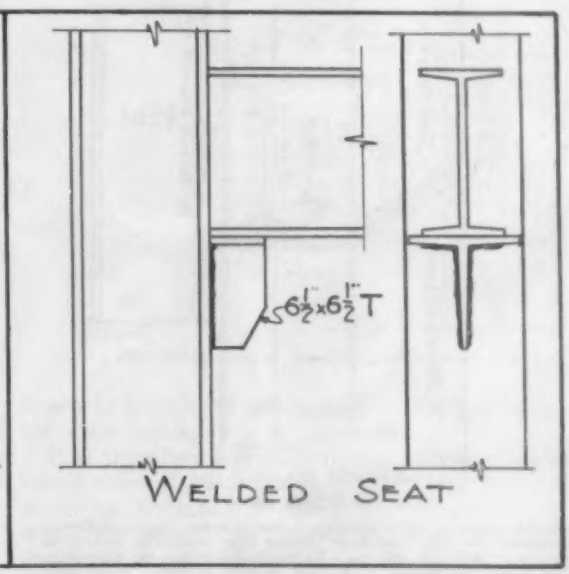


Fig. 13—Welded Beam Seat Equivalent of Fig. 12

those indicate a uniformity very closely checking the writer's previous statement in this respect.

We have previously mentioned proper procedure and inspection. By "Proper Procedure" we mean proper size, length and sequence of beads, proper electrodes, proper currents for the work, proper equipment and, lastly, proper preliminary tests of each operator to determine his fitness and ability to properly weld, and

Fig. 13A—Addition to Factory of The Lincoln Electric Company, Cleveland, Ohio, in Which Bolted Temporary Connections Were Used Till Building Could Be Squared, Plumbed and Then Permanently Arc Welded

regular tests of the operator during the progress of the work.

Such tests have already been standardized by the American Welding Society for preparation of the welding specimens previously mentioned.

We have referred also to proper inspection and a word in regard to this might be in order. Considerable progress has been made in devising methods for testing welds which are non-destructive, but so far as the writer knows none of these have yet been brought to the point where it might be said they are practical for the field. So visual inspection remains the most practical and is the one most used for field work. To the uninitiated, all welds may look alike, but to one experienced in arc welding the appearance of the finished bead will indicate to a remarkable degree the dependability and strength of the weld.

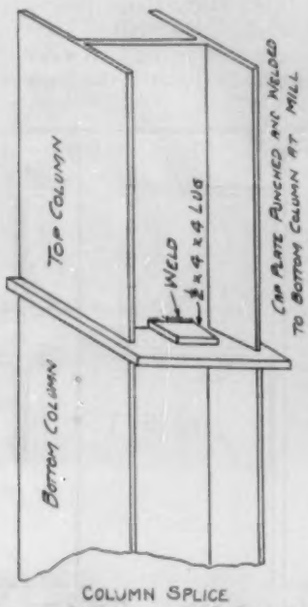


Fig. 14—Column Splice

This sketch shows a column splice between same size or different size columns. In this case field bolting lugs would be welded to top column at mill. A cap plate having holes to line up with bolting lugs would be welded to bottom column at mill. Field connection would be bolted. Field welding would be horizontal between flanges of top column and cap plate

No doubt the completion of the testing program of the Welding Society will develop some very interesting data as to reliability, dependability and working strengths of welds. However, from a large number of welds which our company and others have made, the

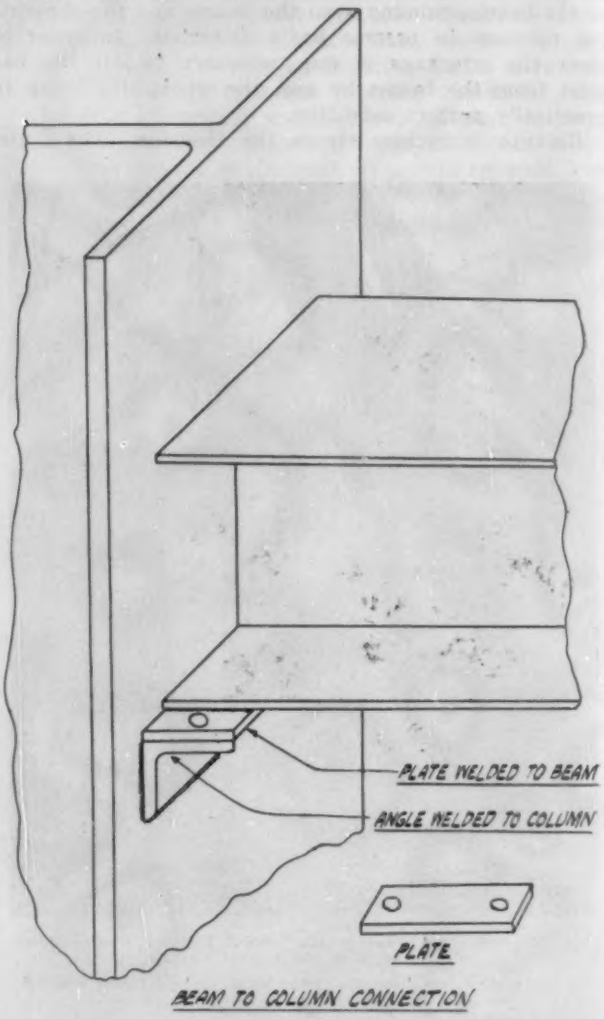


Fig. 15—Beam to Column Connection

This sketch shows a beam to column connection where the beam is narrower than the column. Here a flat plate would be welded to the bottom flange of beam and an angle would be welded to column, each provided with holes for field bolts. Above welding to be done at mill. Field connection would be bolted. Field welding would be horizontal across beam flanges and vertical along web if required

following working values for shear and tension have been found to be safe, practical and conservative:

3/16"	Full Fillet Weld.....	1,500 pounds per lineal inch
1/4"	Full Fillet Weld.....	2,000 pounds per lineal inch
5/16"	Full Fillet Weld.....	2,500 pounds per ineal inch
3/8"	Full Fillet Weld.....	3,000 pounds per lineal inch
1/2"	Full Fillet Weld.....	3,500 pounds per lineal inch

For welds in compression values 20 per cent above those given in the table may be used.

These values are based on the use of a good grade bare or lightly coated electrode.

The question, however, which is probably heard most is: Why weld structures at all? The answers, as the writer sees it, are two:

1. Elimination of noise.
2. Possible economies.

Of course, there are many, many cases where the elimination of the noise of the riveting gun is most

desirable at any cost, and recently public notice has been largely focused on this phase, or advantage, of structural welding; but it is the writer's belief that in the long run the widespread use of arc welding in structural work is going to depend on whether or not savings in dollars and cents can be made over the present methods used and it is a remarkable fact that so far there have been no savings, or at least very little, where structures have been entirely or largely fabricated and erected by welding.

However, that there is a saving in the amount of steel necessary is unquestionable. Due to the possible use of continuous beams, the stopping of columns at

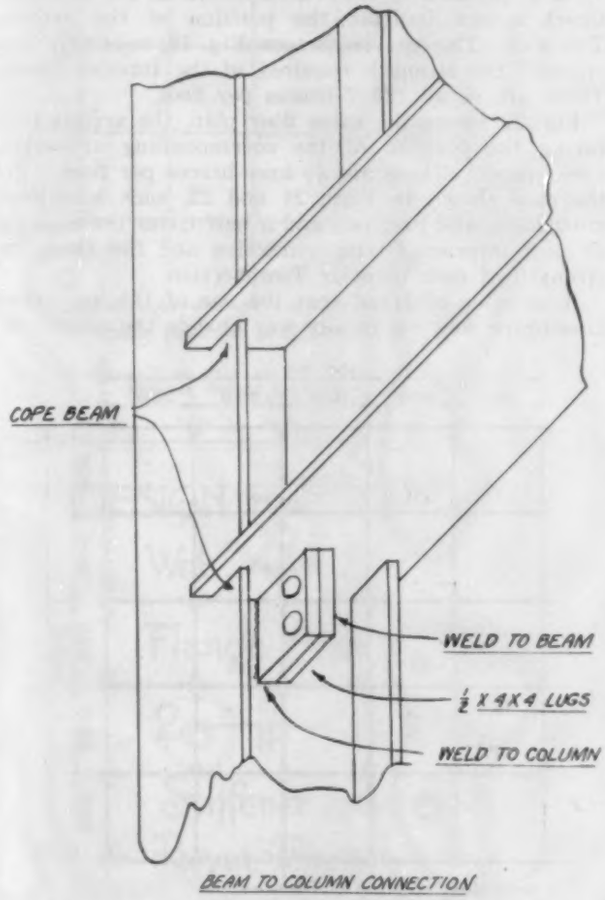


Fig. 16—Beam to Column Connection

This sketch shows a beam to column connection, the beam being wider than column and framing into web of column. In this case the beam flange would be coped to clear column flanges. Field bolting lugs would be welded to beam and column as shown. Field connection would be bolted. Field welding would be horizontal across beam flanges and vertical along web if required

each floor, the elimination and reduction in number of angles, plates, etc., for connections, it is estimated on good authority a saving of steel of 15 to 20 per cent is possible.

As an example of the latter saving, comparative designs of a riveted seat and a welded seat is shown.

Fig. 12 shows a familiar riveted connection—a beam seat designed for a load of 45,000 lb. It consists of a 6-in. by 4-in. by ⅜-in. seat angle, a ⅜-in. fillet, a 3-in. by 3-in. by ⅜-in. stiffener angle, 12 in. long, and 8¾-in. rivets. While Fig. 13 shows the corresponding arc-welded connection. It consists of a piece of 6½-in. by 6½-in. T, 3 in. long, and 18 in. of ⅜-in. fillet weld. Similar examples are numerous.

These savings in steel have been largely wiped out in welded structures through difficulties in erection and other problems, such as too much welding due to extreme conservatism or caution of the designer, too much overhead or inaccessible welding, which is much slower than horizontal welding.

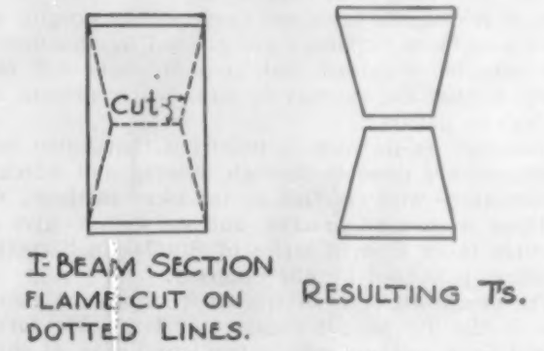


Fig. 17—Prevailing Style of Windbracing, Known as the T-Type

Difficulties or increased cost in erection came from the trouble in—

1. Holding or clamping members in place till they can be welded.
2. Plumbing or squaring the building, etc.

These difficulties can, of course, be overcome by using a few holes in the various members to permit bolting in place until the building can be plumbed and squared and welded permanently. This scheme has been used in a number of cases and costs obtained which compare favorably with riveting. One such case was an addition 60 ft. by 200 ft. to the factory building of our company. This scheme has numerous advantages and some disadvantages. It permits the work to proceed as in riveted construction, with which every erector or fabricator is familiar. Naturally, any work with which one is familiar proceeds more rapidly than work with which one is unfamiliar. Its disadvantages lie in the fact that when used necessarily the members must be put through the fabricating shop, entailing an additional operation, and it is almost as

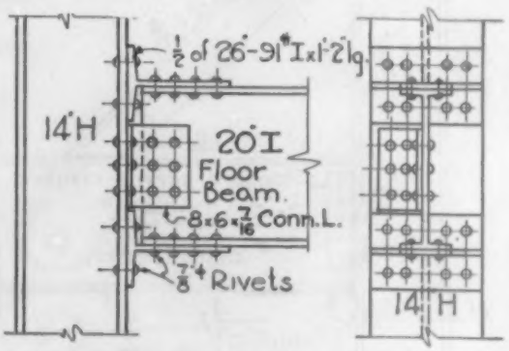


Fig. 18—Method of Riveting T-Type Wind Brace

cheap to punch several holes for riveting as it is one for such bolting.

It is therefore self-evident that considerable economy would arise if the advantage of bolting over clamping could be utilized, provided the structural members would not have to go through the fabricating shop, but go direct from mill to job.

Such a procedure was indicated as being possible in a paper presented to the American Welding Society

some time ago by Mr. J. F. Lincoln. In substance, the plan is to utilize angles, lugs, etc., which have been punched and prepared in the fabricating shop and welded to the structural members on the job. To illustrate, several examples are given from this paper. Figs. 14 to 22 are presented merely as suggestions rather than as typical details.

It is reasonable to expect that as time goes on and more and more buildings are erected by this process and experience gained that erection costs will come down so that the savings in steel will represent real savings in dollars.

However, we do wish to point out that today many economies are possible through welding and which do not interfere with erection by the usual methods. One of those is in wind bracing, and we wish to give our example taken from a series of Studies in Structural Welding, published by our company.

The prevailing style of riveted wind-bracing connection is the T-type. It consists of large T's formed from I-beam sections split in two lengthwise, as shown in Fig. 17.

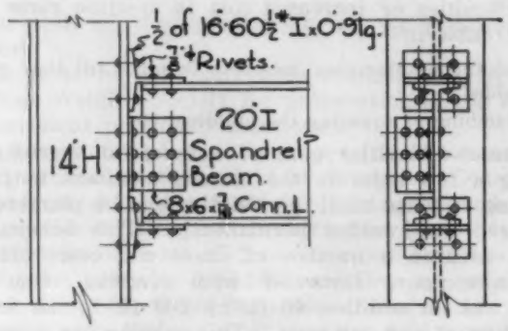


Fig. 19—Method of riveting T-Type Wind Brace

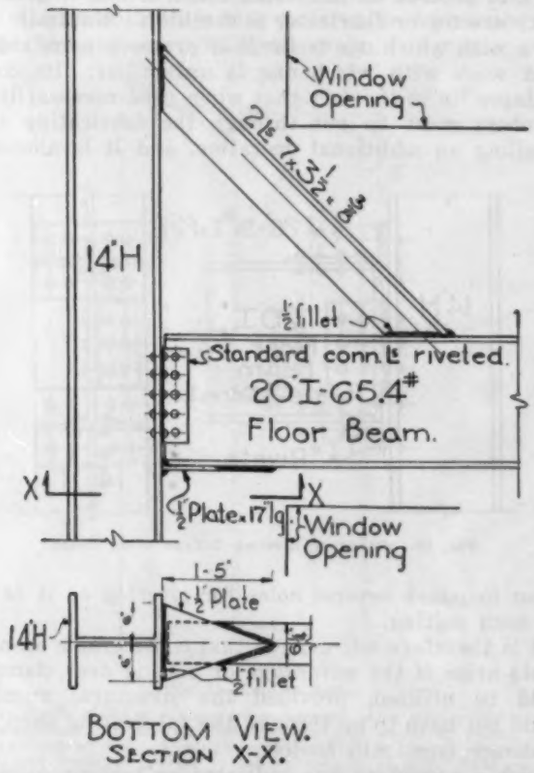


Fig. 20—Arc Welded Knee-Brace Which Can Many Times Advantageously Replace Riveted T-Type

These large T's are riveted at the shop to the columns by a suitable number of rivets and field-riveted to the beam flanges, as shown in Figs. 18 and 19.

It is often possible to replace advantageously the riveted T-type wind brace by the arc-welded knee-brace type shown in Fig. 20.

The knee braces are placed only at the intersection of the spandrel beams and wall columns, the floors being usually well able to transfer the lateral strains to the wall bracing systems. To illustrate the point, consider the floor plan, Fig. 21, of a recently built 40-story structure.

The position of the riveted T-braces, detailed in Fig. 17, are indicated by the crosses shown on the floor plan. Check marks indicate the position of the exterior T-braces. The exterior braces, Fig. 19, need only have one-half the strength required of the interior braces. There are in all 120 T-braces per floor.

Fig. 22 shows the same floor plan, the arrows indicating the position of the corresponding arc-welded knee-braces. There are 40 knee-braces per floor. For the case shown in Figs. 21 and 22, each knee-brace must have, and has, two and a half times the strength of each interior T-type connection and five times the strength of each exterior T-connection.

It is to be observed that the use of the arc-welded knee-brace does not in any way change the usual erec-

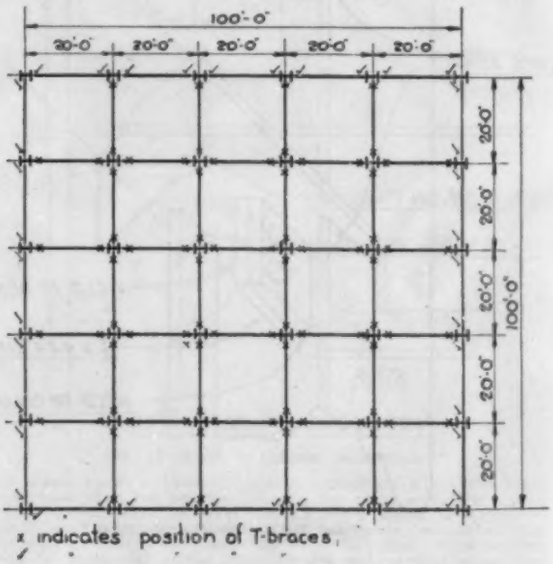


Fig. 21—Floor Plan Recent 40-Story Building

Crosses show position of interior T-type riveted wind brace, check marks show position of exterior T-type riveted wind braces. (Figures 18 and 19)

tion procedure. The steel is raised, set, bolted up temporarily and plumbed in the ordinary fashion and then riveted together by means of the beam connection angles. Only when this has been done are the knee-braces placed and welded in position.

Evidently such a procedure is bound to speed up the job, not to delay it, since the riveters have less rivets to drive to obtain a well squared and plumb structure. The welder operators follow the riveters without interfering with them, and without getting in the way of the masons back of them.

For purposes of comparison, Fig. 23 shows a riveted knee-brace connection corresponding to the arc-welded connection shown in Fig. 20 and of exactly the same strength.

Shop rivets cost about 4c. each; field rivets 22c. each and the large T's and fabricated connections 6c. per lb., and welding, in the positions indicated, averages about $1.25 per lin. ft. On this basis, the cost of the 120 riveted T-brace connections per floor is $1,334; that of the corresponding 40 riveted knee-braces $1,164. The cost of the 40 arc-welded knee-braces, including the riveted standard connection angles, is only $826 or one-third to one-fourth less than the cost of the riveted types of wind-bracing. In all cases the cost of the standard or other load carrying

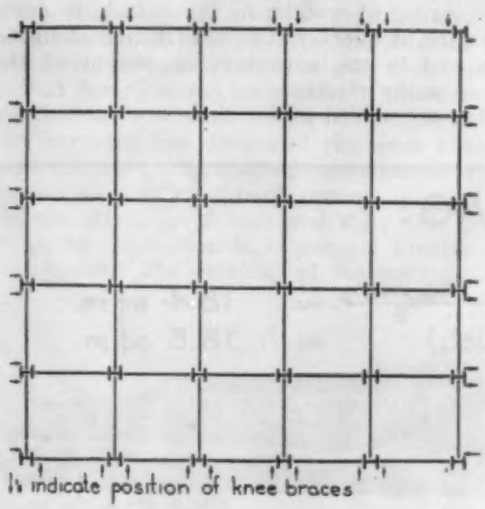


Fig. 22—Same Floor Plan as Fig. 21, But Showing Location of Possible Welded Knee-Type Wind Brace

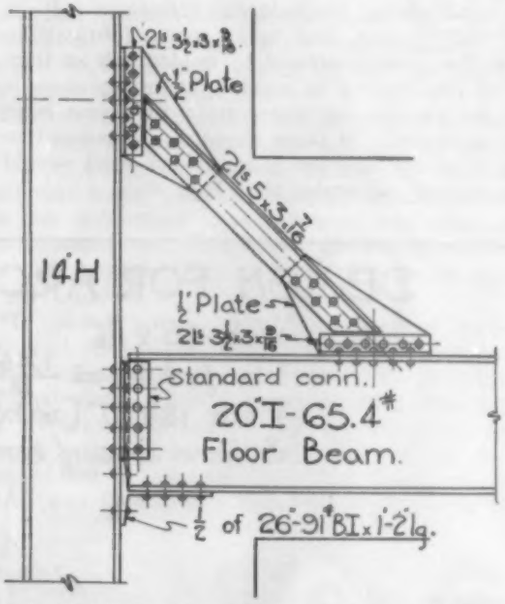


Fig. 23—Riveted Knee-Brace Connection. Compare with Fig. 20

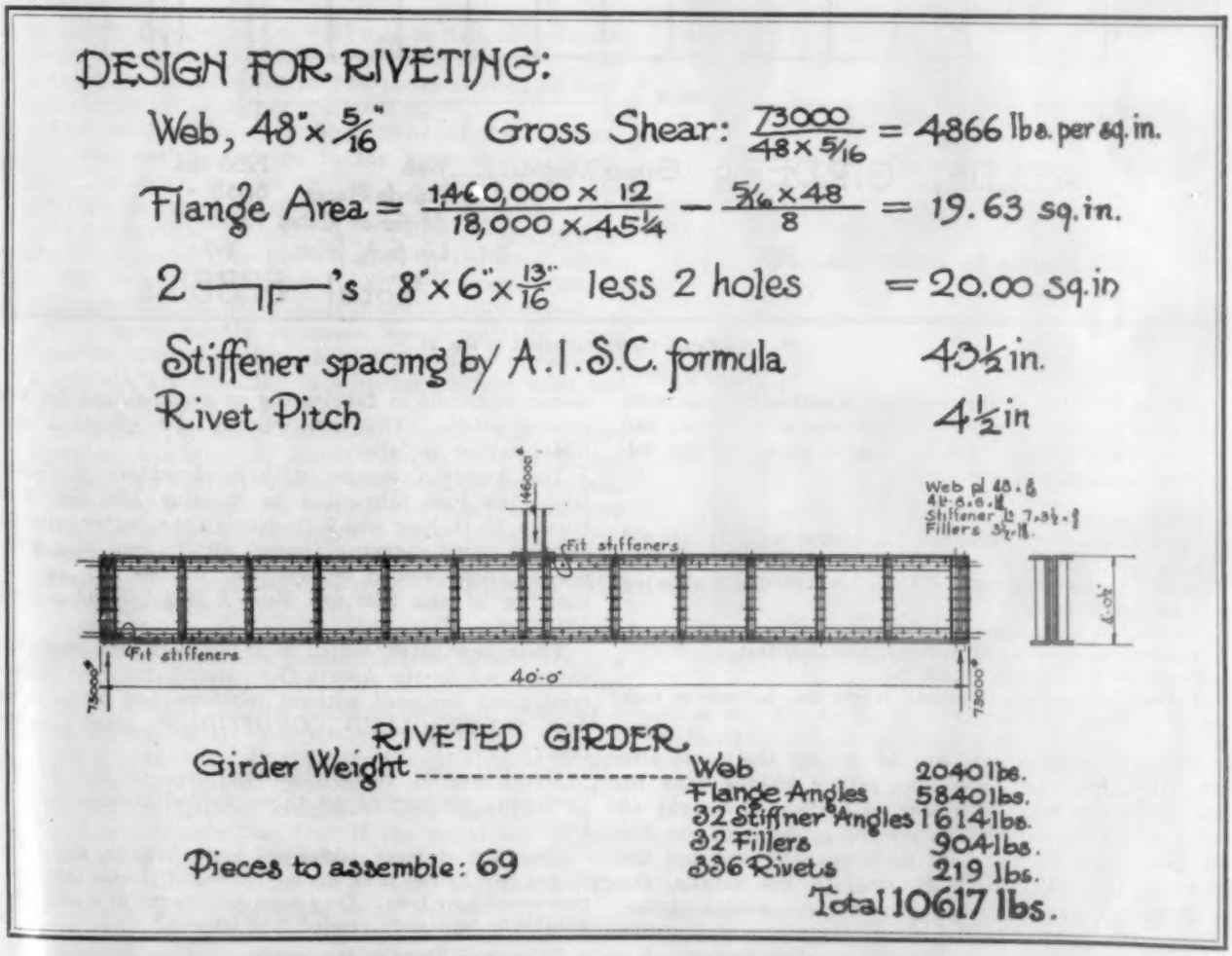

DESIGN FOR RIVETING:
Web, 48" x 5/16"
Gross Shear: 73000 / 48 x 5/16 = 4866 lbs. per sq. in.
Flange Area = 1,460,000 x 12 / 18,000 x 45¼ − 5/16 x 48 / 8 = 19.63 sq. in.
2 ⊢ 's 8" x 6" x 13/16" less 2 holes = 20.00 sq. in
Stiffener spacing by A.I.S.C. formula 43½ in.
Rivet Pitch 4½ in
146000
Fit stiffeners
Web pl 48 - ⅜
Stiffener L 7 x 3½ - ⅜
Fillers 3½ - ⅜
Fit stiffeners
40'-0"
73000
73000
RIVETED GIRDER
Girder Weight
Web 2040 lbs.
Flange Angles 5840 lbs.
32 Stiffner Angles 1614 lbs.
32 Fillers 904 lbs.
336 Rivets 219 lbs.
Total 10617 lbs.
Pieces to assemble: 69

Fig. 24—Riveted Girder Designed for 40 Ft. Span, Concentrated Load of 146,000 Lbs.

connection is figured in the total. On tall structures the saving effected by use of arc-welded wind-bracing represents an amount that cannot be ignored.

This brings us to a point previously mentioned—that in fabricating shop there are real economies possible, unhindered by external influences. It is, however, unfortunate that today many fabricating shops assess the same overhead to welded job as they do to riveted jobs, which is manifestly unfair since welding does not require anywhere near the same equipment, floor space, etc. If these shops would assess true overhead it is our opinion that welded work would show even greater economies than they do.

48-in. plate; the gross shear is not increased since the continuous welding of flanges to web make the effective web height the full height of the girder, as in a rolled beam.

The reduction in flange weight is due to there being no holes to be deducted from the gross section and also to the moment arm being a little longer in the welded than in the riveted girder.

The saving of weight in the details is due to the elimination of fillers, to the substitution of lighter stiffeners and to the advantage in weight of the weld metal over the rivets.

In the arc-welded girder there are one-half as many

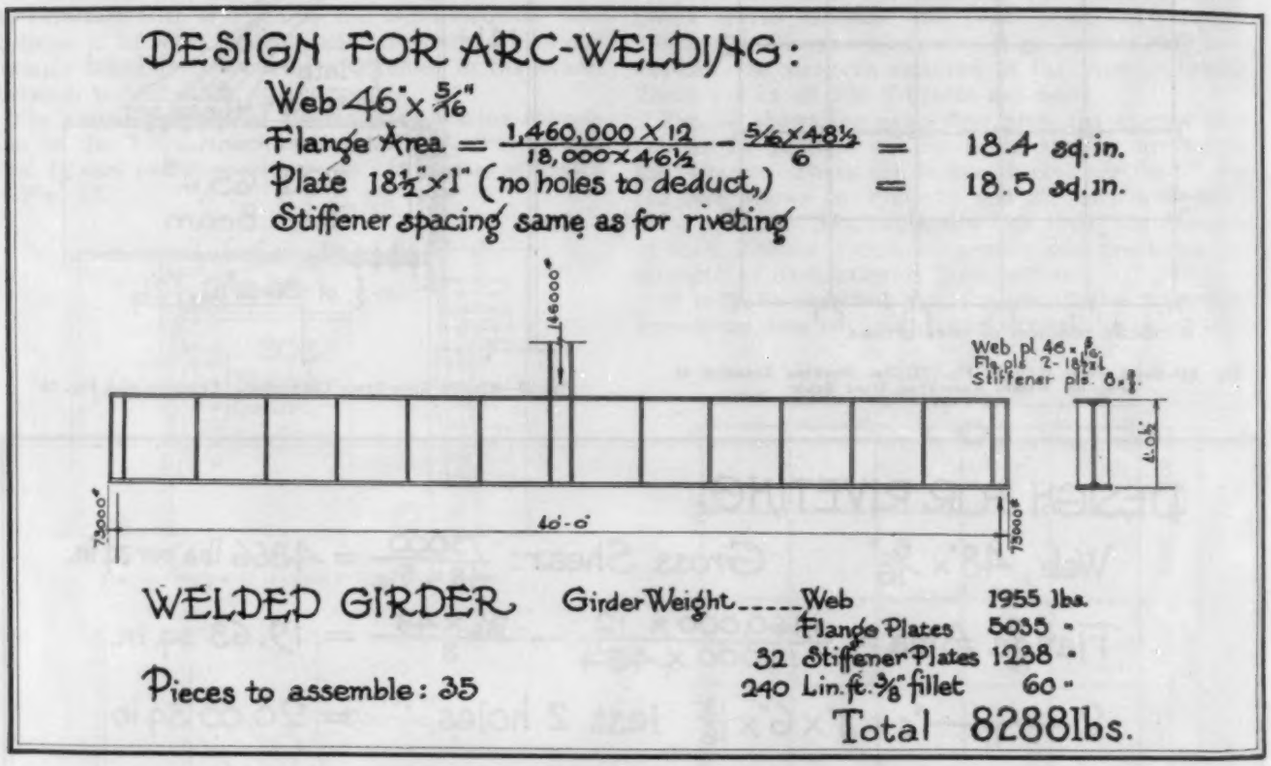

DESIGN FOR ARC-WELDING:
Web 46" x 5/16"
Flange Area = 1,460,000 X 12 / 18,000 X 46½ − 5/16 X 48½ / 6 = 18.4 sq. in.
Plate 18½" x 1" (no holes to deduct,) = 18.5 sq. in.
Stiffener spacing same as for riveting
146000#
Web pl 46 x 5/16
Fl. pls 2-18½ x 1
Stiffener pls. 8 x ⅜
4'-0½"
73000#
40'-0"
73000#
WELDED GIRDER
Girder Weight ____ Web 1955 lbs.
Flange Plates 5035 "
32 Stiffener Plates 1238 "
240 Lin. ft. ⅜" fillet 60 "
Total 8288 lbs.
Pieces to assemble: 35

Fig. 25—Welder Girder Equivalent to Fig. 24

As an example of the economy possible in shop work we wish to show comparative designs of a riveted and welded plate girder. Let us take a girder of the following assumed requirements:

Girder span—40 feet.

Load (including allowance for girder weight) 146,000 lbs., concentrated at a center of span. Design of flanges to be made by the standard "Flange Area Method," allowing for web's resistance.

Spacing of stiffeners not to exceed depth of girder.

Bending moment to be resisted, 1,460,000 feet-lbs.

Shear to be resisted, 73,000 lbs.

Flange stresses not to exceed 18,000 lbs., per square inch on net section.

Though both girders are of exactly the same size and strength, the arc-welded girder weighs 2329 lb. less than the riveted girder, a saving in weight of steel of 22 per cent. The riveted girder requires 890 lb. more steel in the main members, the web and the flanges, and 1439 lb. more steel in the details, the stiffeners, fillers and rivets than the arc-welded girder. The saving of steel in the web of the arc-welded girder is made possible by use of a 46-in. plate instead of a

pieces to handle in fabricating as are required for the riveted girder. Thus arc welding also effects a material saving in labor.

The Austin Company, with headquarters at Cleveland, has just fabricated by welding 136 flat type trusses 75 ft. long and 9 ft. deep in the center, also 63 parallel chord carrying trusses 40 ft. long and 8 ft. deep. These welded trusses are for the new factory building of the Simonds Saw & Steel Company of Fitchburg, Mass.

Their new plant, which is being both designed and constructed by the Austin Company, is the first industrial plant designed without windows and is also the first "CONTROLLED CONDITIONS" plant in industry.

Mr. Harry E. Stitt, chief engineer of the Austin Company, commented on these welded trusses as follows:

"They are stronger, stiffer and better trusses, also 15 to 20 per cent lighter than similar trusses of riveted construction would have been. They were constructed at a cost comparable to equivalent riveted type trusses."

There are literally thousands of other examples, far

too many to attempt to enumerate in this paper. It is safe to say that this phase of structural welding will increase perhaps more rapidly than field work, but it is also safe to say that both phases of this work will proceed rapidly as the knowledge of welding spreads and as refinements of welding itself appear, and refinements and improvements of the process are appearing.

One of the latter-day developments is the economical and practical application of the shielded arc. The desirable results of welding with the shielded arc have been known for years, but it is only comparatively recent that developments have made it practical and economical.

Our company has developed two such methods, one of which is especially adapted to structural work. This is known as the "Fleetweld" process.

Tensile strength of butt welds by this process on steel up to .30 carbon is in general greater than the parent metal. The ductility of the weld metal also is

Fig. 26—Part of Shipment of 136 Trusses 70 Ft. Long and 63 Trusses 40 Ft. Long, from The Austin Company, Cleveland, Ohio, for New Building of Simonds Saw & Steel Company, Fitchburg, Mass.

extremely good, since the weld may be flanged or forged either hot or cold without any sign of fracture. The percentage of elongation on test pieces showed an average elongation of 25 per cent in 2 in.

The weld produced by the "Shielded Arc" process will also resist corrosion to the same degree as the plate, or more so, due to the absence of oxide and nitrides in the weld metal.

In general the speeds obtained by this new process are much faster than that obtained by the usual metallic arc process. Welds up to three times as fast on edge and also on heavy plate welding are obtained.

This very greatly increased speed partially comes from the fact that a much higher voltage is obtained across the arc resulting in a higher wattage used and therefore greater heat.

Increased wattage and size of electrode require therefore machines of ample capacity and of higher voltage than ordinarily used with metallic arc welders.

Welds can be made in vertical and overhead position as well as downward, although in these cases as a general rule the speed is somewhat less than in a down position. However, the quality of the deposited metal will be the same.

These remarkable results are due to the fact that the weld is made in a protective atmosphere. It is a well known fact that where bare or lightly coated electrode is used in making the weld that the metal as it goes across the arc and while in the molten state is exposed to the air. During this time it absorbs oxygen and some nitrogen, resulting in reduced tensile strength, in reduced elongation and ductility. It is also a well known fact that if the metal can be protected from the air while it is molten, the result will be a weld in which the weld metal partakes of the characteristics of the plate being welded.

By this new process exactly this is being done, since the welding is done with a shielded arc. (See Fig. 27.)

"A" shows two parallel square bars fused into each other for two-thirds their length by the Shielded Arc. Part of the welded portion of this sample was then forged and twisted while hot through an angle of 360 deg.

Another part of the sample shown in "A" is illustrated in "B." This sample was obtained from the sample "A," but was twisted through an angle of 720 deg. after being forged.

The effects of corrosion are illustrated by the sample "C." This sample was immersed in a 10 per cent solution of sulphuric acid for 72 hours. The left-hand weld was made with an uncoated electrode. Close inspection will reveal that this bead was badly pitted in the corrosion test. The hight-hand weld was made by the new process. Notice the difference in the effects of corrosion on these two beads.

"D" shows a test bar formed by butt welding two pieces of steel plate. The surplus weld metal was machined off so that the weld was only as thick as the original plate. Two holes were then drilled through the weld and the sample pulled. When the break occurred in the plate as shown, the pull on the sample was 54,000 lb. per sq. in., The stress on the weld metal was 60,900 lb. The higher stress on the weld

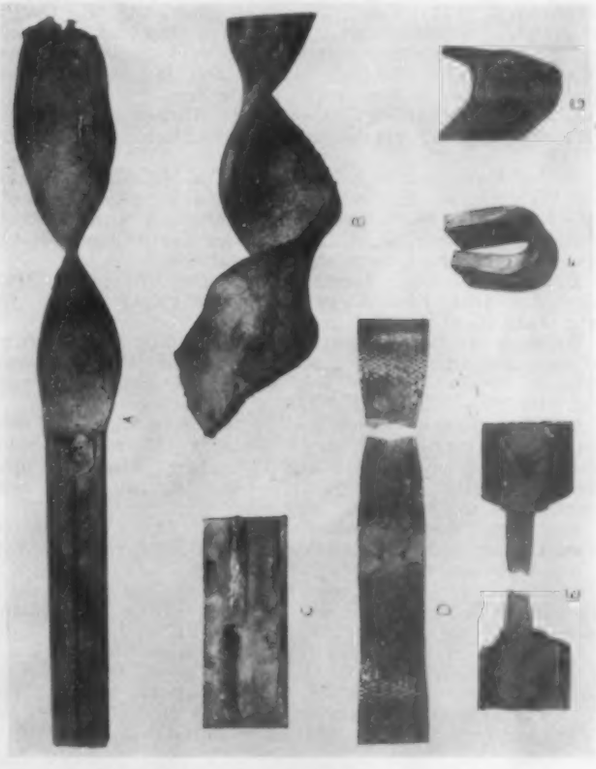


Fig. 27—Some of the Results Obtained with a Shielded Arc

metal was due to the fact that the cross sectional area of the weld metal was reduced by the two holes drilled through it. Before testing the round drill holes were .182 of an inch in diameter. After the sample was pulled this dimension was increased to 17/64 in., or an elongation of from 40 per cent to 45 per cent.

A test bar composed entirely of weld metal is shown in "E." The weld metal was machined into the rectangular bar as shown and then pulled. The test showed that the weld metal had an ultimate strength of 62,500 lb. per sq. in. and that the yield point was

24,500 lb. per sq. in. The elongation in 2 in. was 30 per cent.

"F" shows two bars which were butt welded and the resultant bar then bent as shown, with the weld as the pivoted point.

"G" also illustrates the extreme ductility of welds produced by the Shielded Arc. The lower weld which broke when bent was made by an uncoated electrode. The upper weld in this sample was made by the new process.

So when you see and review the strides which have been made in the very few years that structural welding has known, it is indeed difficult to forecast the future, but the forward looking fabricator or erector would do well to embrace every opportunity to study this young but sturdy child—ARC WELDING.

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Section Activities

(*Continued from page* 4)

School of Applied Science on February 20. The speaker for the evening was W. R. Ost, Engineer of the Air Reduction Sales Company. His talk was on the "Trend in Transmission Pipe Line and Compressor Station Welding." The meeting was very well attended and everyone present seemed to enjoy the talk and the discussion after the paper had been completed. Mr. Ost's paper was illustrated by slides showing the actual conditions confronted in pipe line work and covered fully the problems in pipe line and compressor station welding.

DETROIT

An invitation has been received from the Industrial Electrical Engineering Society to attend their meeting on Wednesday, February 18, which will be held in the Colonial Room, Masonic Temple. C. J. Holslag of the Electric Arc Cutting and Welding Company will speak on the subject of "Arc Welding."

The next meeting of the Detroit Section will be on March 24 with a talk by P. W. Fassler of the Fisher Body Corp., on Resistance Welding. The April meeting will be on the 28th. C. E. Swift of the Westinghouse Electric & Manufacturing Company will present a paper on Arc Welding.

NEW YORK

The New York Section held a joint meeting with the New York Chapter of the American Society for Steel Treating on March 9, at which J. J. Crowe of the Air Reduction Sales Company was presiding officer. The subject of the meeting was "Non-Destructive Tests of Welds," and three important papers dealing with the subject were presented as follows: "X-Ray Inspection of Welds," by Dr. Ancel St. John, St. John X-Ray Corporation. (This paper was presented by H. R. Isenberger, an associate of Dr. St. John.) This paper was a complete treatment of the whole subject including important applications. "Magnetic Inspection of Steel Products," by Dr. A. V. De Forest, Magnetic Physicist, Welding Engineering and Research Corp. (This paper was presented by A. B. Kinzel of the Union Carbide and Carbon Res. Lab.) This paper included a review of the outstanding developments in the use of magnetic testing in industry. "Gamma-Ray Inspection of Heavy Welded Structures," by Dr. R. F. Mehl, Naval Research Laboratory, Anacosta, Md. This covered the development of a new method for the examination of very thick material. Motion pictures and lantern slides accompanied these papers, as well as a motion picture by Bausch & Lomb Optical Company.

NORTHERN NEW YORK

On February 6 a very interesting meeting was held by the Northern New York Section. The speakers were T. H. Booth of the Buffalo Forge Company and H. T. Florence of the Cleveland Crane and Engineering Company. Mr. Booth spoke on the use of arc welding in the manufacture of bar cutters, bending rollers and other machines built by his company. He also gave interesting comparisons of savings in cost of welded construction over the use of castings. His talk was illustrated. Mr. Florence spoke about the application of welding in the construction of cranes. He gave numerous illustrations of the superiority of welded over riveted construction for the box girders and other parts of cranes. His lecture was also illustrated.

The March meeting will be held as a joint meeting with the Student Chapter of American Society of Civil Engineers, on March 11. Prof. F. P. McKibben, Consulting Engineer, will speak on "Welding of Steel Buildings and Bridges."

PHILADELPHIA

The Philadelphia Section will hold its March meeting on the 16th in the Auditorium of the Engineers Club, 1317 Spruce Street, at 8 o'clock. James W. Owens, Director of Engineering, Welding Engineering and Research Corporation, will talk on "Residual Stresses."

PITTSBURGH

An over-flow meeting of the Pittsburgh Chapter was held Wednesday night, February 18, when a paper on the "Latest Developments in Welding of Boilers and Pressure Vessels," was presented by C. W. Obert, Consulting Engineer, Union Carbide and Carbon Research Laboratories, Inc., Long Island City.

This meeting was attended by one of the most interested group yet called together to listen to a paper on welding, and seemingly some one in every branch of industry in that district had some interest in the paper that was presented by Mr. Obert, and the results were most gratifying. The officers and members were highly complimented by many of those present for the interesting papers and authors that have been brought to Pittsburgh and they were all enthusiastic about the progress that is being made in welding lines. The discussion after the paper was read lasted for an hour and a half with many of Mr. Obert's points more fully illustrated by means of chalk talks.

PORTLAND

On February 3 the Portland Section held a meeting in the Multnomah Hotel, Room 101. Three reels of pictures furnished by the Lincoln Electric Company showed in considerable detail the application of welding methods in the erection of the Upper Carnegie Building in Cleveland. These were followed by two films furnished through the courtesy of the same firm illustrating the welding operations on a gas line between Vera Cruz, Mexico, and the international boundary.

SERVICES AVAILABLE

Opportunities.—The Society is glad to learn of desirable opportunities from responsible sources, announcements of which will be published without charge in the BULLETIN.

Services Available.—Under this heading brief announcements (not more than seventy-five words in length) will be published without charge to members. Announcements will not be repeated except upon request received after an interval of three months; during this period, names and records will remain in the office reference files.

Note.—Copy for publication in the BULLETIN should reach the Society's Office not later than the thirtieth of the month if publication in the following issue is desired. *ALL REPLIES should be addressed to the number indicated in each case and mailed to the Society headquarters.*

A-122. Welding engineer desires position. Have had extensive experience in design work, structural steel, ornamental work and specialties. Have also had charge of shop fabrication and field erection work.

A-123. Electric welder desires permanent position. Eleven years' experience. Prefer to connect with reliable firm who employ one welder on maintenance or production work.

A-124. Welder experienced on Acetylene and Electric Welding. Can furnish references.

A-125. Aircraft welder desires position. Six years' experience in aircraft work, of which four years were with a well-known engineer on experimental jobs. Thoroughly familiar with all manner of aircraft welding and on the various metals used in same, including aluminum and its different alloys. Has instructed students and had a year's experience as welding foreman for an aircraft concern. References.

FOR VALUE RECEIVED

A GREAT MANY PEOPLE will tell you that the biggest single service that five cents can buy today is a local telephone call. Without question, it is big value . . . and value that steadily grows as new telephones come into your neighborhood.

There are times when telephone service is priceless . . . when the ability to call instantly a doctor, a policeman, or the fire department could not be measured in terms of money.

But it is not alone the emergencies that give the telephone its value. There are the commonplaces of every-day conversation . . . in the home, the shop, the office . . . whenever you wish two-way communication with any one, almost anywhere.

The telephone has become such an every-day, matter-of-fact convenience—like running water and electricity—that it is natural to take it for granted. It is well to pause occasionally and consider the nation-wide organization of men, money, and materials that makes this vital service possible, and at such low cost.

Here is a system of the public, for the public . . . run on the barest margin of profit consistent with service, security, and expansion. A service that grows as the community grows . . . placing within the reach of an increasing number the means to talk back and forth with people in the next block, the next county, a distant state, a foreign country, or on a ship at sea!

No other money that you spend can bring you more actual value.

★ *AMERICAN TELEPHONE AND TELEGRAPH COMPANY* ★

BELL SYSTEM

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